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APPENDIXES V AND X, OHIO SHORE LINE OF LAKE ERIE BETWEEN ASHTABULA AND THE PENNSYLVANIA STATE LINE, BEACH EROSION CONTROL STUDY

LETTER

FROM

SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, UNITED STATES ARMY, DATED OCTOBER 22, 1951, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A COOPERATIVE BEACH EROSION CONTROL STUDY OF THE OHIO SHORE LINE OF LAKE ERIE BETWEEN ASHTABULA AND THE PENNSYLVANIA STATE LINE, PREPARED UNDER THE PROVISIONS OF SECTION 2 OF THE RIVER AND HARBOR ACT APPROVED JULY 3, 1930, AS AMENDED AND SUPPLEMENTED; TO THE COMMITTEE ON PUBLIC WORKS, AND ORDERED TO BE PRINTED WITH ILLUSTRATIONS

JANUARY 28, 1952.—Referred to the Committee on Public Works

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LIST OF APPENDIXES MADE IN CONNECTION WITH THE REPOR OF THE DISTRICT ENGINEER

(Only appendix 5 printed)

1. Aerial photographs.
2. Ground photographs.
3. Existing structures.
4. Probings and analyses of bluff and beach samples.
5. Estimate of benefits and costs.

LIST OF PLATES MADE IN CONNECTION WITH THE REPORT OF TH DISTRICT ENGINEER

(Only pls. 1, 6, and 7 printed)

1. Sheet 1. General plan.
2. Sheet 2. Comparative profiles.
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6. Sheet 6. Proposed plans of improvements.
7. Sheet 7. Proposed plans of improvements.

LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY,
Washington 25, D. C., January 24, 1952.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am transmitting herewith a report dated October 22, 1951, from the Chief of Engineers, United States Army, together with accompanying papers and illustrations, on a cooperative beach erosion control study of the Ohio shore line of Lake Erie between Ashtabula and the Pennsylvania State line, appendices V and X, prepared under the provisions of section 2 of the River and Harbor Act approved on July 3, 1930, as amended and supplemented.

A copy of the letter containing the views of the director, Department of Public Works, State of Ohio, is enclosed.

The Bureau of the Budget advises that, while there is no objection to the presentation of the report for the consideration of Congress, authorization of the project, which the Chief of Engineers considers inadvisable for the United States to adopt at this time, would not be in accord with the program of the President.

Sincerely yours,

FRANK PACE, Jr.,
Secretary of the Army.

LETTER OF TRANSMITTAL

COMMENTS OF THE STATE OF OHIO

STATE OF OHIO

DEPARTMENT OF NATURAL RESOURCES,
Columbus, October 16, 1951.

Brig. Gen. C. H. CHORPENING,
Assistant Chief of Engineers, United States Army,
Washington 25, D. C.

DEAR SIR: Your letter of September 26, 1951, to the director of the Ohio Department of Public Works, together with a copy of the proposed report of the Chief of Engineers and the reports of the Beach Erosion Board and the district and division engineers, in connection with the cooperative beach erosion control study of the Lake Erie shore line between Ashtabula and the Pennsylvania State line, appendixes V and X, has been referred to this office since the Division of Shore Erosion has been transferred from the Department of Public Works to the Department of Natural Resources.

Please be advised that this office concurs, in general, in the views and recommendations of the Chief of Engineers as outlined in his letter to the Secretary of the Army.

Very truly yours,

F. O. KUGEL,
Chief, Division of Shore Erosion.

APPENDIXES V AND X, OHIO SHORE LINE OF LAKE BETWEEN ASHTABULA AND THE PENNSYLVANIA STATE LINE, BEACH EROSION CONTROL STUDY

REPORT OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY

DEPARTMENT OF THE ARMY,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 22, 1951.

Subject: Beach erosion control report on State of Ohio, appendixes V and X, Ashtabula to the Pennsylvania State line.

To: The Secretary of the Army.

1. I submit for transmission to Congress a report, with accompanying papers, on a beach erosion control study of a portion of the shore of Lake Erie in Ashtabula County, Ohio. The study was made by the Corps of Engineers in cooperation with the State of Ohio, under the provisions of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented.

2. After full consideration of the reports of the district and division engineers the Beach Erosion Board concludes that the need for protection of the publicly owned sections of the shore within the study area is insufficient to warrant Federal aid under the policy established by Public Law 727, Seventy-ninth Congress. For the privately owned portions of the shore, the Board recommends that private owners adopt one of the plans of protection proposed by the district engineer, selecting that most suitable to the physical characteristics and desired use of their shore frontage, consistent with the effect on adjacent shore sections. As existing Federal law does not include a policy of Federal aid in the cost of protecting privately owned shores, no Federal participation in the cost of the work is recommended. Accordingly, the Beach Erosion Board recommends that no project be adopted by the United States at this time for the protection or improvement of the shores of Lake Erie within the area studied.

3. The Beach Erosion Board states its opinion as required by law, as follows:

(*a*) It is inadvisable for the United States to adopt a project authorizing Federal participation in the cost of protecting and improving the Lake Erie shores of Ohio within the area studied;

(*b*) Except for recreational benefits in connection with improvement of Conneaut Township Park, the public interest in the proposed work is small;

(*c*) No share of the expense should be borne by the United States.

4. After due consideration of these reports, I concur in the views and recommendations of the Beach Erosion Board. Because of their general interest to the public and their value to local authorities, I recommend that these reports with selected illustrations, be published.

LEWIS A. PICK,
Lieutenant General, Chief of Engineers.

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REPORT OF THE BEACH EROSION BOARD

BEACH EROSION BOARD,
CORPS OF ENGINEERS,
Washington 16, D. C., August 1, 1951.

Subject: Beach Erosion Control Report on Cooperative Study of the Ohio Shore Line of Lake Erie, appendixes V and X, Ashtabula to the Pennsylvania State line.

To: The Chief of Engineers, United States Army, Washington 25, D. C.

1. This report is on a study of beach erosion in cooperation with the State of Ohio under authority of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The purpose of the investigation is to determine the best methods of preventing further erosion of and stabilizing the existing shore, and of restoring and creating new beaches. The State desires that emphasis be placed on determining effective and economical methods of shore protection, and on the possibilities of development and improvement of publicly owned park and beach areas.

2. The area studied is located in Ashtabula County on the south shore of Lake Erie from 58 to 72 miles east of Cleveland, Ohio. It lies between a point about 1¼ miles east of the mouth of the Ashtabula River and the Pennsylvania State line, a distance of about 14 miles. Ashtabula Harbor, located just west of the study area, and Conneaut Harbor, located near the east limit of the study area, have been improved by the United States for navigation.

3. Ashtabula County had a population of about 69,000 in 1940. The principal centers of population are the cities of Ashtabula and Conneaut which had populations of about 21,400 and 9,400 respectively. The property along the shore line of the study area has been developed mainly for private residential and recreational purposes. The principal summer colonies are in the village of North Kingsville. The population of the shore area is increased somewhat by summer visitors. Inland areas are devoted mainly to agricultural uses.

4. The shore is publicly owned at the Conneaut water works, Conneaut Township Park, and Lake View Park. The latter lies within Conneaut Harbor. Its beach is not suitable for bathing. Conneaut waterworks and Lake View Park are not in need of additional protection at this time. Conneaut Township Park is used for recreational purposes. It has a wide beach for about the eastern half of its frontage. The remaining portion has a narrow beach and the bluff is subject to erosion. The remainder of the shore within the study area is privately owned except for a short stretch along the highway at Whitman Creek, which is adequately protected at present.

5. The shore line of the study area consists generally of eroding bluffs 40 to 80 feet high of clay, silt, sand and gravel fronted by narrow beaches of sand and gravel. The bluffs are founded on shale which varies in elevation from about 4 feet above to 4 feet below low-water datum. The bluffs are the major source of beach material in the study area. Probably no material reaches the area from west of Ashtabula Harbor and little is supplied by tributary streams. Analysis of samples of bluff material indicated that in general approximately 13 percent of the material is suitable for beach building in the western half of the study area and 27 percent in the eastern

alf. Erosion of the bluffs thus makes available some beach ma-erial in the eastern half of the study area. West of Conneaut water-vorks and Conneaut Harbor relatively wide beaches have formed by ccretion caused by the structures extending into the lake.

6. Miscellaneous groins and sea walls have been constructed in an ttempt to prevent erosion of the shore. Short groins have generally aused minor accretion on their west sides and have reduced recession f the bluffs to some extent. The pronounced accretion west of the arbor structures and the accretion west of short groins indicate a marked eastward predominance of littoral drift.

7. The mean level of Lake Erie in the study area is about 2 feet bove the established low-water datum. The highest stage recorded nd the highest monthly mean are respectively about 5 and 4 feet bove that datum. The greater fetch and movement of winds from he westerly quadrant account for the predominance of eastward ittoral drift. Due to the limited size of Lake Erie, local storms are he sole cause of important wave action. Short waves rise quickly during storms and may reach heights of 8 or 10 feet in deep water. Due to the gently sloping offshore bottom, waves of this height ordi-narily break before reaching shore structures. The maximum wave eight that need be considered in designing structures where no pro-tective beach will remain is probably 4 feet. Existing groins with shore ends about 5 to 6 feet above low-water datum indicate that these elevations are generally adequate to impound a low protective beach without entirely preventing desirable distribution of available material along shore. However, during storms at high lake stages, waves may occasionally reach the toe of the bluff over beaches of this elevation and armoring of the toe may be desirable. Where a higher protective beach is desired, so that armoring will be unneces-sary, an elevation of 8 feet for the top of the groin should be used. Ice forms a protective coating over beaches during winter months, but the lifting and battering action of shifting ice floes during the spring break up must be considered in designing shore structures for structural stability.

8. The shore areas immediately east of Ashtabula and Conneaut Harbors are subject to pollution by sewage discharged untreated into those harbors. Under normal conditions no apparent hazards from sewage contamination from Conneaut Harbor exist at the beach area of Conneaut Township Park. Pollution at Lake View Park located within that harbor is considered hazardous to the health of bathers. No hazards from pollution appear to exist in the remainder of the study area.

9. The district engineer has considered the desires of the cooperating agency, has determined the sources and movement of beach material, the changes in the shore line and offshore bottom, the effects of winds, waves, ice and storms, the effects of existing structures, and has developed a plan for protecting and improving Conneaut Township Park and five general plans for protecting and improving the privately owned shores of the study areas. He concludes that for the western half of the study area where an adequate supply of beach material is lacking, the most economical and practical general plan of protection consists in grading and draining of the bluffs and armoring of the toe of the slope. Three methods of armoring are presented for use under varying bluff conditions. For the eastern half of the study where a

larger supply of beach material is available, he presents two plans o protection. One comprises grading and draining the bluff, armorin the toe of the slope and maintenance of a protective beach by mean of short groins. Where the bluffs contain a considerable proportio of beach material and no structures are located so close to the top o the bluff as to necessitate positive protection against any furthe recession of the bluff, a less costly plan using high short groins may b used. Under this plan the slope would not be armored and erosio of the bluff would be permitted to fill the groin system. The groi system would operate to retard erosion of the beach and the beac might be expected to build up to protect the toe of the bluff. H recommends that owners of private property adopt one of the fiv proposed plans of improvement best suited to the physical character istics and the desired utilization of their shore front property. H further concludes that Conneaut Township Park is the only publicl owned section of the shore line where additional protection or improve ment is needed at this time and that the plan best suited to the need and resources of the township consists of one cellular steel-pile groin He recommends, subject to certain conditions, that a project b adopted by the United States authorizing Federal participation to th extent of 31 percent of the first cost of the groin construction a Conneaut Township Park.

10. The division engineer concurs in the conclusions and recommen dations of the district engineer.

11. The Beach Erosion Board was not convinced that participatio by the United States in the cost of construction of the recommende plan for Conneaut Township Park is justified, because the benefit from prevention of damages from erosion are inconsequential and th improvement anticipated from the proposed work within a period o 7 years would develop as a result of natural processes without con struction in a period of 25 years. In view of the foregoing, the Boar was of the opinion that the development of this park beach shoul not be considered eligible for Federal aid under Public Law 727, Seventy-ninth Congress, which provides for Federal contributio toward the construction of protective works. The Board so notified local interests. No communications were received as a result of thi notice.

VIEWS AND RECOMMENDATIONS OF THE BEACH EROSION BOARD

12. The Board has carefully considered the reports of the reporting officers. It concurs generally in their views and recommendations, subject to the comments contained in the following paragraphs.

13. The Board notes that the reporting officers present five methods for protecting the shores of privately owned property and recommend that owners adopt the plan best suited to the physical characteristics and desired utilization of their shore front property. Typical protective measures are illustrated on plate 6 of the report. Plans A, B, and C include grading and draining the bluff and protecting the toe of the slope by stone revetment, a metal crib sea wall or a cellular steel sheet pile sea wall. Plan D includes grading and draining the bluff, armoring the toe of the slope with stone revetment and maintaining a protective beach by a system of short groins. Plan E permits

ormation of a protective beach by controlled erosion of the bluffs, vith short groins to retain the beach thus formed. The Beach Erosion Board concurs in these methods of protection and in the manner of selection of the type best suited to each particular section f shore, as proposed by the district engineer. It wishes to emphasize he desirability of coordinated action by owners within a section to rotect a stretch of frontage under the plan of protection best suited or the privately owned shores in that section, and the necessity of dequately protecting the ends of the work to prevent flanking.

14. The Board recommends that private owners adopt one of the lans of protection proposed by the district engineer, namely, plan , stone revetment of the toe of the slope, plan B, metal crib sea wall, lan C, cellular steel sheet pile sea wall, plan D, armored slope and nort groins, or plan E for short groins with controlled erosion of he bluff, selecting that most suitable to the physical characteristics nd desired use of their shore frontage, consistent with the effect on djacent shore sections. As existing Federal law includes no policy f Federal assistance in the cost of protecting privately owned shores, o Federal participation in the cost of the foregoing work is recom- ended at this time.

15. The Board has reviewed the prospective benefits for the project or Conneaut Township Park recommended by the reporting officers. notes that the value of the park land subject to erosion is low and hat at the past rate of erosion, the anticipated annual loss amounts only $245 annually. Similar incidental benefits from protection adjacent private property amounts to $215 annually. The annual osts of protection are $1,425. Because of the inconsequential pro- ective benefits, the Board considers that the need for protection is sufficient to warrant Federal aid under the provisions of Public aw 727, Seventy-ninth Congress. Moreover, the Board notes that mprovement anticipated from the proposed work in a period of 7 ears would develop as a result of natural processes in a period of 25 ears. The total benefits warrant consideration of the construction the proposed project at local expense, however, the Board recom- ends that local interests independently evaluate the urgency of eed for added recreational facilities in determining justification for ndertaking the work.

16. In accordance with existing statutory requirements, the Board ates its opinion that:

(*a*) It is inadvisable for the United States to adopt a project author- ing Federal participation in the cost of protecting and improving the ake Erie shores of Ohio within the area studied;

(*b*) Except for recreational benefits in connection with improve- ent of Conneaut Township Park, the public interest in the proposed ork is small;

(*c*) No share of the expense should be borne by the United States.

17. The Board recommends that no project be adopted by the nited States at this time for the protection or improvement of the ores of Lake Erie within the area covered by this report.

For the Board:

E. E. GESLER,
Colonel, Corps of Engineers,
President.

At the time of adoption of this report the members of the Beac Erosion Board were: Col. E. E. Gesler, Corps of Engineers, president Dean Thorndike Saville, State of New York; Dean Morrough O'Brien, State of California; Dr. Lorenz G. Straub, State of Minne sota; Col. W. P. Trower, Corps of Engineers; Col. R. W. Pearson Corps of Engineers.

REPORT OF THE DISTRICT ENGINEER

SYLLABUS

The purpose of the cooperative beach erosion control study is to determin effective and economical methods of shore protection and beach stabilization the Ohio shore line of Lake Erie between the easterly limit of Lake Shore Par immediately east of the city of Ashtabula and the Ohio-Pennsylvania State lin with particular emphasis on the protection and improvement of publicly owne property.

As a result of this study it is concluded that:

(1) Conneaut Township Park is the only publicly owned property requirin further improvement and protection at this time.

(2) The plan of improvement most suitable for the protection and improv ment of Conneaut Township Park frontage is the construction of a groin to co centrate the supply of natural littoral drift along the westerly 680 feet of pa frontage that is now experiencing erosion. The total estimated cost of the proje is $22,600.

(3) Five general plans of improvement are suitable for use in this study ar for the protection and improvement of privately owned property. Plan which consists of stone revetment at the base of the bluff and, where necessar grading and drainage of the slope, is suitable where the amount of sand carrie by littoral drift is negligible and earth pressure on the landward face of t improvement can be economically eliminated. The metal-crib sea wall propos in plan B is an alternative plan to be used under similar conditions where so lateral support is required. Along the balance of the shore line where the amou of sand carried by the littoral currents is negligible, and heavy surcharge loa on the shore protection structure cannot be economically eliminated, plan will be the most practical. Plan C provides a cellular steel sheet pile sea w at the toe of the bluff and grading and drainage where necessary. Plan which consists of low groins and slope revetment, is suitable for retaining improving the existing narrow beaches and preventing further erosion of t base of the bluff.

The proposed plan E can be used at locations where there is a high percenta of beach building material in the bluff. The relatively high short groins a designed to hold material derived from controlled erosion of the bluff itself build a protective beach which will gradually stabilize the toe of the bluff.

It is recommended that the United States adopt a project authorizing Feder participation in the cost of the improvement at Conneaut Township Park subje to certain specified conditions. The total cost of the project is estimated to $22,600, of which the Federal contribution is $7,000. The balance of the co of the project will be assumed by local interests.

It is also recommended that owners of private property adopt one of the pr posed plans of improvement found to be best suited to the shore-line characte istics, location, and the intended use of the shore-front property to be improve

CORPS OF ENGINEERS, UNITED STATES ARMY,
OFFICE OF THE DISTRICT ENGINEER, BUFFALO DISTRICT,
Buffalo 7, N. Y., August 2, 1950.

Subject: Beach Erosion Control Report on Cooperative Study of t Ohio Shore Line of Lake Erie, Appendixes V and X

To: The Division Engineer, Great Lakes Division, Corps of Engineer Chicago 15, Ill.

I. GENERAL

1. *Authority.*—This cooperative beach erosion control study w initiated by formal applications from the State of Ohio, acting throu the department of public works, for appendixes V and X to t

original agreement dated March 5, 1942, for a cooperative beach erosion study of the Ohio shore line of Lake Erie. The applications were approved December 9, 1948, and entered into under authority conferred by section 2 of the River and Harbor Act of July 3, 1930, as amended and supplemented. Appendixes V and X were combined in order to consider the entire physiographic unit between harbor structures at Ashtabula and Conneaut in a single report and expedite completion of the study.

2. The study of beach-erosion and shore-protection problems was made by the United States acting through the Corps of Engineers, United States Army, and the State of Ohio acting initially through the department of public works and later through the department of natural resources to which the duties of administration of beach-erosion control were assigned by the State on or about November 15, 1949.

3. *Purpose.*—The purpose of this study was to make a comprehensive beach-erosion-control study of approximately 14 miles of shore line in Ashtabula County, Ohio, extending from approximately 1¼ miles east of the Ashtabula River eastward to the Ohio-Pennsylvania State line. In the study of the area within these boundaries, the State of Ohio desired to have emphasis placed on determining effective and economical methods of shore protection, and on the possibilities of development and improvement of publicly owned park and beach areas.

4. *Prior reports.*—No prior beach-erosion-control studies covering the shore line of the immediate study area have been made. However, navigation reports have been made on Conneaut Harbor which is in the study area, and on Ashtabula Harbor which lies immediately to the west. Table 1 lists reports in which there are data pertinent to beach erosion or shore protection.

TABLE 1.—*Prior reports*

Title	Date	Document No.	Congress and session	Remarks
Reexamination and survey report on Conneaut Harbor, Ohio.	Sept. 30, 1915	983	64th, 1st	Recommended removal of remaining portion of old west breakwater and modification of alinement of new west breakwater.
Preliminary examination and survey report on Conneaut Harbor, Ohio.	May 26, 1931	48	73d, 1st	Recommended extension of the west breakwater to shore.
Preliminary examination and survey report on Ashtabula Harbor, Ohio.	May 28, 1915	997	64th, 1st	Do.

II. LOCATION AND DESCRIPTION

5. *Location.*—The study area lies on the south shore of Lake Erie in Ashtabula County, Ohio. It extends from the easterly limit of Lake Shore Park, immediately east of the city of Ashtabula, eastward to the Ohio-Pennsylvania State line. The area is shown on United States Lake Survey Charts 3, 33, and 34, and in greater detail on plates [1] and aerial photographs [2] accompanying this report.

[1] Only plates 1, 6, and 7 printed.
[2] Not printed.

6. *Description.*—The shore line, which runs in an east-northeasterly direction, is devoid of natural headlands. The harbor installations at Ashtabula and Conneaut provide the principal irregularities in an otherwise straight shore line. The shore line, like most of that in Ohio, is characterized by bluffs composed of easily eroded material, and ranging from 40 to 80 feet in height. Narrow sand and gravel beaches, some of which are submerged during periods of high water, are found in front of the bluffs. A more detailed description of the bluffs and beaches is given in paragraphs 23, 24, and 30–33.

7. Ashtabula Harbor, immediately west of the study area, is located at the mouth of the Ashtabula River about 57 miles easterly from Cleveland Harbor, Ohio. The lower 1.9 miles of the Ashtabula River and an outer harbor of 185 acres formed by a breakwater system are maintained as a Federal project. The city of Ashtabula is an industrial and shipping center, two railroads having constructed large ore- and coal-handling wharves in the river and outer harbor.

8. The westerly 2,000 feet of the study area is occupied by a steam-electric generating plant owned by the Cleveland Electric Illuminating Co. Approximately 1,800 feet to the east of this plant, the Electro Metallurgical Co. has recently constructed a similar plant which occupies approximately 1,000 feet of shore line. The new steam-electric generating plant provides power for the adjacent industrial development. With the exception of the small residential-recreational areas adjacent to the plants, and Camp Luther, east of Labounty Road, the balance of the area in Ashtabula Township bordering the lake is largely devoted to farming.

9. North Kingsville Village, extending 4¾ miles east of Whitman Creek, occupies the entire lake-shore frontage of Kingsville Township. There are several private recreational developments here which consist of small summer residential areas and camps. The easterly section of the township is more highly developed than the westerly section. The principal summer colonies are located at Kingsville-on-the-Lake, Valley Brook allotment, and the Terrace Beach allotment. Various religious organizations maintain summer camps near the eastern limit of North Kingsville Village. Among them are Camp Calvary, the Akron YWCA, and the Ashtabula Baptist Association.

10. The balance of the study area lies within the former boundaries of Conneaut Township, which has recently been incorporated as Lakeville Village. The shore line of Lakeville Village west of the city of Conneaut has been developed for residential and recreational purposes. The balance of Lakeville Village shore line lies between the city of Conneaut and the Ohio-Pennsylvania State line. A beach formed by natural accretion fronts the bluffs in this area. The undeveloped property is owned by the Carnegie-Illinois Steel Corp.

11. Conneaut Harbor, a Federal deep-draft navigation project, is located at the mouth of the Conneaut River about 29 miles west of Erie, Pa. The harbor comprises the lower 3,000 feet of the Conneaut River and an outer harbor area of approximately 142 acres protected by breakwaters. In 1923, the Federal Government granted a permit to the Bessemer and Lake Erie Railroad to remove and reconstruct a portion of the United States west pier at Conneaut Harbor. In addition, the company was also granted permission to reclaim a stretch of land about 1,100 feet wide, adjacent and approximately parallel to the west pier. This project, although abandoned before

completion, resulted in the construction of the existing west pier and a dike which enclosed a rectangular area west of the pier. Because the enclosed area was only partially backfilled, a small enclosed lagoon was formed landward of the dike. Recently, the railroad ceded a portion of the area to the city of Conneaut, which has developed it as a small boat harbor. In 1949, the city cut a channel through the original dike and built a small dike on their east property line.

12. There are several stretches of publicly owned property along the shore line of the city of Conneaut. The city waterworks is located approximately 2,600 feet east of Whitney Road. Conneaut Township Park, one of the two parks within the city limits, extends 1,800 feet east of Chestnut Street. Approximately 50 feet of the park frontage is east of the inner end of the west breakwater shore arm in Conneaut Harbor. The beach is open to the public without charge and bathhouse facilities are available. The park frontage is divided by a small stream which enters the lake approximately 100 feet west of the bathhouse. The shore line of Lake View Park extends 1,200 feet within the confined limits of Conneaut Harbor. A limited improvement of the park was initiated in 1934. It consisted of sloping and terracing the bluffs along the park frontage, but in 1935, the project was abandoned before its completion. In 1942, a severe storm removed a 25-foot section of the terrace. At the present time, the park frontage does not have a beach suitable for bathing.

13. *Population.*—The population of Ashtabula County, Ohio, was 68,674 in 1940. This total includes the following political subdivisions within the limits of the study area: The city of Conneaut with a population of 9,355, the township of Kingsville with 2,064, and the village of Lakeville with 2,973. Ashtabula Township, which extends 1,600 feet west of the study area, had a population of 3,037. The population of the area under consideration fluctuates somewhat during the year due to the presence of small summer communities throughout the area.

14. *Pollution.*—In commenting upon the quality of the waters along the shore of Lake Erie between the mouth of the Chagrin River and the Ohio-Pennsylvania State line, which includes the entire shore line covered in detail by this report plus the shore line for approximately 35 miles west of the study area, the State of Ohio, Department of Health reports as follows:

* * * The water along the lake front between these points is relatively uncontaminated, except for areas in the immediate vicinity of sewer outlets from large municipalities, which are rather widely separated. The normal direction of flow along the shore in the lake is toward the east and the wind is generally from the west. Hence, bathing beaches located to the west of municipalities are generally relatively safe except under abnormal weather and adverse wind conditions.

When the provisions of a new law recently passed by the legislature become effective, it will be illegal for municipalities to discharge untreated sewage into the streams and lakes in the State and a penalty is provided for violation of this statute. This law should give an impetus toward the construction of adequate sewage treatment facilities by communities along the lake. Already a number of cities and villages along the lake have taken preliminary action on this problem. It is not anticipated that there will be a rapid elimination of all of the sources of pollution entering the lake; however, there will be a gradual improvement. When adequate sewage facilities are installed, devices will be provided for special treatment during the bathing season. There are relatively few existing beaches along the lake where it would not be possible by the installation of feasible improvements to eliminate the potential sources of contamination of the beaches.

Many thousands of people are now using the various beaches along the lake front, and the public is beginning to recognize the importance of conserving these

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points of recreation. Hence, there is an increasing demand for protection of bathing beaches from even occasional contamination. In general, we anticipate a marked improvement in the conditions of water of the bathing beaches along Lake Erie.

15. The principal source of pollution in the study area is from the discharge of untreated sewage and waste from the industrial and urban centers at Ashtabula and Conneaut Harbors. At the present time, the city of Ashtabula has no sewage treatment facilities and the principal sanitary sewer outlet discharges into the lake near the inner end of the east breakwater in Ashtabula Harbor. As stated in the report made by the Department of Health, the predominant currents in the lake and along shore normally move in an easterly direction. Tests of water samples from the Lake Shore Park beach, which is immediately west of the west limit of the study area, taken between June 26, 1946, and August 11, 1947, indicate a relatively high intensity of pollution. Thus, the beaches near the western limit of the study area are subject to serious pollution.

16. A similar condition exists in the city of Conneaut. The untreated sewage is discharged into the Conneaut River and the predominant currents in the lake cause contamination of the beaches east of the city. Under normal conditions, no apparent hazards due to sewage contamination from the Conneaut River exist at the beach area of Conneaut Township Park, which is located west of the west breakwater at Conneaut Harbor. The small stream entering the lake within the park limits is also subject to pollution. However, local health officials consider the existing chemical treatment used for the stream adequate to prevent contamination of the beach.

17. At the present time, the sewage at Conneaut Township Park is chlorinated and discharged into a septic tank; however, the existing sewage treatment facilities are overtaxed during peak attendance days. The effluent does not have time to leach out properly and offensive seepage rises to the surface. While the seepage is not particularly hazardous to the health of the bathers, it is obviously undesirable. The park board plans to remedy the situation by the addition of an overflow tank in the present system. A sump pump will be used to discharge the effluent from the new tank into a proposed extension of the city sanitary sewer system located at the top of the bluff.

18. Lake View Park in the city of Conneaut is approximately 3,000 feet southwesterly from the mouth of the Conneaut River. Because the park is within the confined area of the harbor, the use of Lake View Park beach is considered hazardous to the health of bathers under existing conditions of pollution of the Conneaut River.

III. GEOLOGY AND COAST CHARACTERISTICS

19. *General.*—The bedrock of the south shore of Lake Erie from Sandusky, Ohio, eastward to the Ohio-Pennsylvania State line consists of limestone, dolomite and shale of Devonian age. The rocks are little disturbed from the nearly horizontal position in which they were deposited. All of the rock units lie east of the crest of the Cincinnati Arch and have a general regional dip toward the southeast of 15 to 20 feet to the mile, although there are exceptions in parts of the Cleveland district where the surface rocks dip to the southwest.

20. From Sandusky eastward to approximately 3.7 miles northwest of the Huron River, the uppermost rock is Columbus and Delaware limestone. There are no outcrops along the lake shore, but the bedrock is close enough to the surface to be encountered in basement excavations in the Sandusky area. Lying stratigraphically above the limestone, a narrow belt of Olentangy shale covered by a few feet of glacial drift intersects the Lake Erie shore line about 2 miles northwest of Huron. From this point eastward to the Pennsylvania State line, some unit of the Ohio shale underlies the entire shore line region. Occasionally one or more of the three members of the Ohio shale known as Huron, Chagrin, and Cleveland shale are exposed to the top of the shore escarpments. Sometimes they are found occupying the lower part of the cliffs, or lying just offshore beneath water level. However, they are more commonly covered by glacial material and can be found only by drilling.

21. The formation of the Lake Erie Basin and the geologic characteristics of the surface materials in the Erie Basin are the result of glacial action during the Pleistocine age. During this period, at least two ice sheets advanced from the north-northeast to about 75 miles south of the present shore line, scouring the preglacial soil and bedrock and then depositing glacial soils. Thus, in general, the material overlying the bedrock is a glacial till composed of native material ground up beneath the glacier and mixed with material from the Canadian regions to the east and northeast. The composition of the till varies widely from place to place, but in general, is a hard, compact, boulder clay with the included rock fragments varying from sand size to pebbles, cobbles, and large boulders. On the average, the boulder clay contains approximately 75 percent silt and clay, 15 to 20 percent sand, and the remainder is coarser material. Analysis of bluff samples from the study area are included in appendix 4[1] of this report.

22. Lake Erie is the shallowest of the Great Lakes and is the only one whose bottom does not extend below sea level. It has an average depth of 58 feet and a maximum depth of 210 feet. During the glacial period, water impounded between the ice fronts and the high land forming the divide between the St. Lawrence River and Ohio River drainage basins formed lakes of higher elevations than the present Lake Erie. Beach ridges, roughly paralleling the present lake shore and located from 5 to 10 miles inland, outline the boundaries of the former lakes. There is also evidence that lakes at lower levels than the present one existed. Lacustrine clay and silt deposited in the bottom of the glacial lakes forms the surface material throughout most of the Ohio shore line. In localized areas the surface material is sand probably deposited as outwash from streams of the retreating glaciers. The characteristics of the bluffs in the study area are described in more detail in the following paragraphs.

23. *Coast characteristics.*—In general, the shore line of the study area is characterized by easily eroded bluffs from 40 to 80 feet in height, fronted by narrow sand and gravel beaches which are exposed or inundated depending upon variations in lake levels. The bluffs are founded on shale which varies in elevation from approximately 4 feet below to 4 feet above low-water datum. The underlying shale is exposed at the base of the bluffs east of profile 2 for approximately 5,000 feet. Probings indicate another high shale area at an elevation

[1] Not printed.

of 1.5 feet above low-water datum in the vicinity of profile 25. However, there is no visible rock outcrop in the vicinity of that profile.

24. Overlying the shale there is an undulating stratum of boulder clay which varies from 38 to 65 feet in thickness. Between profiles 33 and 37, the entire bluff face is composed of boulder clay. In the vicinity of profile 10, the boulder clay forms the surface material overlying an intermediate stratum of lacustrine material. In the balance of the study area, sand or sand and gravel forms the surface stratum. An intermediate stratum of lacustrine material appears intermittently in the face of the bluffs throughout the entire study area. Table 2 gives the composition of the bluffs as determined by the State geologist at 12 points spaced throughout the study area.

TABLE 2.—*Composition of bluffs*

Location	Upper stratum		Intermediate stratum		Lower stratum		Rock
	Material	Elevation of top [1]	Material	Elevation of top [1]	Material	Elevation of top [1]	Elevation of top [1]
Profile 1	Sand	63	Sand and clay	45	Boulder clay	41	−4.0
1,600 feet west of profile 2.	do	64	Sandy clay	44	do	38	−1.0
2,000 feet west of profile 3.	do	63	Lacustrine material.	55	do	40	+4.0
500 feet east of profile 3	do	60	Sandy clay	58	do	53	−0.5
Profile 10	Boulder clay	63	Lacustrine material.	48	do	32	−2.0
300 feet west of profile 19	Sand and gravel	67			do	65	−2.5
700 feet west of profile 20	do	70	Lacustrine material.	48	do	34	−4.0
800 feet east of profile 25	do	74	do	47	do	(2)	+1.5
Profile 31	Sand	58	do	52	do	43	−3.0
Profile 33	Boulder clay	48					−1.0
Profile 37	do	52					−0.5
Profile 43	Sandy clay	49	Lacustrine material.	43	Boulder clay	41	−1.0

[1] Elevation in feet referred to low-water datum, 570.5 feet above mean tide at New York City.
[2] Not exposed.

25. *Sources of beach building materials.*—Three possible natural sources of beach building material for any particular section of shore line are erosion of the bluffs and beaches updrift of the area, material brought down by streams, and underwater sand and gravel deposits close to shore. Analyses of samples obtained from the beaches at the water's edge and from underwater at the 6-foot depth contour were made to determine the size of material that can be expected to remain on the beaches and thus estimate what quantities of material suitable for beach building are furnished from the above sources. Samples of the materials in the bluffs and underwater samples at the 18- and 30-foot depth contours were also taken. Locations of the samples are shown on plate 1, and analyses of the individual samples of beach, bluff, and bottom materials are given in appendix 4.[1]

26. *Composition of existing beaches.*—Analyses of 18 samples taken at the water's edge from beaches throughout the study area indicate that an average of 96.1 percent of the material is retained on the No. 140 sieve and 96.2 percent is coarser than the No. 200 sieve, which is approximately the lower limit of grain size of material customarily classified as fine sand. Only two samples were obtained at the 6-foot

[1] Not printed.

depth due to the prevalence of rock at or immediately below the lake bottom. The samples obtained were classified as gravel by visual inspection.

27. *Offshore deposits.*—Sampling operations at the 18- and 30-foot depths were conducted along 18 profile lines spaced throughout the study area. Since, in most instances, samples were unobtainable with available equipment, it was concluded that there was little material overlying the shale on the lake bottom at these depths.

28. *Composition of bluffs.*—Approximately 84 percent of the study area lies between the harbor installations at Ashtabula and Conneaut Harbors. Little of the beach material resulting from erosion of the beaches and bluffs on either side of the study area can be supplied to this section of shore line since the harbor structures impound or deflect lakeward most of the material carried by littoral currents. During temporary reversals of the predominant littoral current, some beach material may enter the balance of the study area east of Conneaut Harbor. Under ordinary conditions, the major portion of beach material derived from bluff erosion must originate within the limits of the study area. It is evident from the average of analyses of beach samples that material finer than the No. 140 sieve is not present on the beaches in significant quantities. Consequently, it is reasonable to assume that material finer than the No. 140 sieve furnished by erosion of the bluffs or from other sources is not suitable for beach building under the existing conditions of exposure to waves and currents in this section of the Ohio shore line.

29. Samples of actively eroding bluffs were taken at six locations throughout the study area. Analyses of bluff samples indicate that an average of approximately 80 percent of the material is finer than the No. 140 sieve. Thus, only approximately 20 percent of the total material in the eroding bluffs in the study area is suitable for nourishment of adjacent beaches.

30. *Existing beaches.*—In general, the only wide beaches in the study area are those accumulated by the impounding action of structures. A long groin built in the early 1900's at Kingsville-on-the-Lake has maintained a beach approximately 400 feet long. The beach has a maximum width of 100 feet adjacent to the west side of the groin. East of profile 20, numerous short groins have impounded material and the narrow beach has resulted in the stabilization of the bluffs.

31. Harrington Point, 700 feet east of profile 27, is a sand point having a maximum width of 150 feet. The point is well protected by a system of groins and sea walls. East of Harrington Point, numerous short groins have impounded material to form a beach that continues east to the Conneaut waterworks. This beach attains its maximum width of 150 feet immediately west of the shore protection structures at the Conneaut waterworks.

32. Approximately 200 feet east of profile 32, a groin has retained material to form a beach approximately 1,000 feet long. The beach attains its maximum width immediately west of the groin. The beach at Conneaut Township Park is approximately 1,100 feet long and has a maximum width of 300 feet. This beach has formed since the construction of the shore arm of the west breakwater at Conneaut Harbor in 1935.

33. East of the city of Conneaut, a beach of varying width extends 8,000 feet to the Ohio-Pennsylvania State line. The beach remains

fairly stable in this section of shore line. East of profile 42, it attains its maximum width of approximately 150 feet.

34. *Streams.*—There are numerous streams entering Lake Erie within the limits of the study area. Investigation of the stream beds and adjacent beaches indicates that in general, the streams cannot be considered significant sources of beach building material. However, during peak flow periods, the streams carry considerable quantities of clay and silt that are deposited in the lake bottom. Descriptions of all streams within or adjacent to the study area are given in the following paragraphs.

35. Ashtabula River, rising about 6 miles inland on the plateau, drains an area of 137 square miles. It flows westerly for 12 miles, then winds in a general northerly direction through a deep gorge for 3 miles, then westerly in a similar manner for 3 miles to emerge on the plain where it flows northwesterly and enters the lake at Ashtabula Harbor. The lower 1.9 miles of the river forms the Ashtabula inner harbor, a Federal deep-draft navigation project.

36. Whitman Creek, which enters Lake Erie approximately 3.6 miles east of the Ashtabula River, has a drainage area of 7.2 square miles. The maximum length of its many tributaries is 3 miles. There are numerous small streams between Whitman Creek and the Conneaut River. These streams, about a mile in length, drain northward into Lake Erie. There are also numerous deep, but very short gullies cut into the shore cliffs which carry water only during the intermittent periods of heavy rainfall.

37. The Conneaut River has a drainage area of 190 square miles. The source of the Conneaut River is located in Summit County, Pa., 25 miles southeasterly of Conneaut Harbor, Ohio. It flows in a northerly direction for approximately 20 miles, turns west and meanders through a deep gorge for approximately 15 miles. The river then turns sharply to the east and continues to flow through the deep gorge to the city of Conneaut, and thence north to enter Lake Erie at Conneaut Harbor. The lower 3,000 feet of the Conneaut River has been improved for deep-draft navigation.

38. Turkey Creek rises 4 miles south of Lake Erie and flows in a general northerly direction entering Lake Erie 1 mile east of Conneaut Harbor. Approximately 9.6 square miles of the total drainage area of 10.5 square miles are located east of the Ohio-Pennsylvania State line.

39. *Probings.*—Twelve probings, spaced throughout the study area, were taken at the water's edge. (See plate 1 for locations.) Bedrock is very close to the surface in this entire stretch of shore line. The maximum elevation of rock obtained by probing was 1.5 feet above low water datum and occurred in the vicinity of profile 25. The average elevation of the underlying rock is 1.8 feet below low water datum. Detailed results of all probings taken are given in appendix 4[1] of this report.

IV. FACTORS AFFECTING SHORE PROCESSES

40. *Wind.*—The wind records at Ashtabula Harbor, as recorded by the United States Coast Guard lifeboat station, have been compiled for the period from January 1937 to December 1948, inclusive, with the exception of 1944. Ashtabula wind records for that year are in-

[1] Not printed.

complete, and for that reason have been excluded from the Ashtabula summary. The resulting data have been converted to yearly averages which are shown diagramatically on plate 1. The wind duration for each direction is classified in three groups of velocities, 0–12, 13–24, and 25 miles per hour and over. The length of each bar on the perimeter of the diagram represents the percentage of the total wind duration for these velocities. The percentage of the total wind movement and duration for each direction is shown in the center of the diagram.

41. The shore line under consideration is exposed to storm waves from the west-southwest through the north to the northeast. In the higher velocities (25 miles per hour and over) winds of the greatest duration came from the northwest, southwest and west, while in the lower velocities, winds of the greatest duration were from the southwest. The maximum wind movement, which is a function of the combined effect of velocity and duration, is also from the southwest. Winds from the southwest are nearly parallel to the shore and the resulting waves create currents along shore in an easterly direction. Storm winds from the west through the north to the northeast are potentially the most damaging because of their greater fetch. Wind data are summarized in table 3 below.

TABLE 3.—*Yearly average winds at Ashtabula Harbor, Ohio*

Direction	Duration, percent of total	Movement, percent of total	Direction	Duration, percent of total	Movement, percent of total
North	4.8	4.8	South	12.5	9.3
Northeast	15.8	16.5	Southwest	23.3	22.7
East	4.3	3.4	West	13.5	13.6
Southeast	9.8	8.2	Northwest	16.0	21.5

42. *Lake levels.*—Variations in lake levels greatly influence the rate of erosion within the study area. Wave attack occurring during high lake stages is more damaging to the bluffs than that occurring during low lake levels because of the reduced effective width and height of the existing protection.

43. Minimum lake levels during any particular year usually occur in February when the precipitation throughout the Great Lakes watershed is being stored in the form of ice and snow. Maximum levels occur in midsummer when the full effect of the runoff from the watershed of Lake Erie and the upper lakes is felt. Fluctuations of considerable magnitude, but of short duration, are caused by wind tides and also by seiches, which are the large waves induced by sharp barometric gradients moving rapidly across the lake. Westerly winds raise lake levels in the study area, while easterly winds tend to lower the lake level. In 1859, the United States Lake Survey established water level gages on all the Great Lakes. One of these is located at Cleveland Harbor, Ohio. Continuous records of monthly mean elevations of all the lakes are available for the period from 1860 to date, and are published by the United States Lake Survey district of the Corps of Engineers. Pertinent data on the fluctuations of levels of Lake Erie, as recorded by the Cleveland, Ohio, gage, are shown in table 4.

TABLE 4.—*Water level fluctuations*

Item	High stage, feet [1]	Date	Low stage, feet [1]	Date	Variation, feet	Elevation
Extreme stage, monthly mean	+4.01	June 1876	−1.07	February 1936.	5.08	
Extreme stage, instantaneous 1900–1949	+5.05	June 1946	−2.85	Feb. 4, 1936	7.90	
Maximum seasonal variation in calendar year.	+3.83	June 1947	+1.08	March 1947	2.75	
Minimum seasonal variation in calendar year.	+1.08	June 1895	+.21	November 1895.	.87	
Mean lake level		From January 1860 to December 1949, inclusive.				572.29
		From January 1900 to December 1949, inclusive.				571.96
Average lake level for months April to November, inclusive.		From 1900 to 1949, inclusive				572.22

[1] Referred to low water datum, 570.5 feet above mean tide at New York City. All stages computed from monthly means, except instantaneous high and low.

44. *Ice action.*—Under suitable conditions, ordinarily in the late fall, spray freezes and forms a coating of ice on the shore to heights up to 15 feet above lake level, thereby armoring the beach and bluffs against further wave action. As soon as solid ice forms offshore, the shore line is protected from further wave action for the period in which the ice is intact. Early in December of average winters, ice starts to form in the shallow water along the shore of Lake Erie. During the most severe winters, the entire lake may freeze over and the ice attain a maximum thickness of approximately 3 feet. In average years, the warmer weather of early March weakens and honeycombs the ice. Subsequently, the ice breaks up and forms floating ice fields that shift with the winds. If the break-up extends to the shore, floating ice cakes batter the shore structures. Frequently, ice is shoved up on the shore causing additional damage to weak structures.

45. While ice has both detrimental and beneficial effects, the latter are believed to predominate because of the protection provided to the shore line during the winter when storms are most severe and wave action would otherwise be most destructive. The protective effect of ice was illustrated during the storm of March 25, 1947. At that time, the east end of Lake Erie, which was protected by ice, was undamaged, while serious damage occurred in the Cleveland, Ohio, area and to the west where the lake was free of ice.

46. *Water seepage and frost action.*—The rate of erosion caused by the slumping of material from the face of the silt and clay bluffs is hastened by the action of ground water, surface runoff and frost action. Although in some sections of the shore line the bluff material is relatively impervious, it contains enough thin lenses of sand to allow percolation of ground water to the face of the bluff. Shrinkage cracks occur near the surface, both at the top and along the face of the bluff, and allow surface water to enter and further soften the bluff material. Freezing of the water in these cracks along the face of the bluffs hastens the disintegration process. Large sections fall off and slide down to the base of the bluff where wave action removes the fine materials. Unprotected bluffs cannot attain a stable slope and the process of slumping and removal of material by wave action goes on in a continuous cycle, the rate dependent to a large extent upon lake levels and the severity of wave attack.

47. In some sections, the lacustrine material is covered by a layer of sand and gravel. Rain falling upon the highly pervious sand percolates through to the less pervious lacustrine material below. Part of the water emerges along the cliff face, at the point of contact between the sand and the lacustrine material in the form of a contact spring. This water flowing down the face of the bluff removes some of the easily eroded lacustrine material. Some of the water soaks slowly through the lacustrine materials, increasing the weight and reducing the friction between the fine particles. This causes movement of the lacustrine clay over the impervious boulder clay below. This viscous mass acts like material commonly called quicksand. Ordinarily there are other contact springs in the face of the bluff at the top of the boulder clay.

48. *Littoral drift.*—In the study area, winds from the southwest through the west to the northwest set up currents along the shore in a general west to east direction. Those from the north and northeast set up currents in the opposite direction. Offshore winds from the south through the southeast to the east have little effect on the littoral current. The wind diagrams on plate 1 and the data in table 3, paragraph 41, show that winds from the southwest, west, and northwest, account for approximately 53 percent of the total wind duration, and 58 percent of the total wind movement. Only 21 percent of the total wind movement and duration is accounted for by north and northeast winds. Predominant winds of high velocity are from the northwest, southwest, and west. Under the influence of this wind pattern, the prevailing and predominant littoral currents are from west to east with temporary reversals in direction due to winds from the north and northeast. Accretion adjacent to the shore structures confirms this analysis. Outstanding examples are the sand beaches which have accumulated west of the breakwater at the Conneaut water works and west of the west breakwater shore arm at Conneaut Harbor, Ohio.

V. EXISTING STRUCTURES

49. *Existing structures.*—There are many types of structures which affect shore processes in the study area. These range from privately owned timber crib groins built for shore protection, to large rubble mound breakwaters erected as protective structures for navigation. The location of all structures observed during the field investigation of the study area is shown on plates 4 [1] and 5.[1] A brief description of the structures shown on these plates is given in appendix 3 [1] of this report. The descriptions contained in the following paragraphs are confined to the principal structures and their effect on the shore line. The beach widths given in connection with the descriptions were those existing at the time of survey but are subject to considerable seasonal variation. For ease in orienting the structures described, the number or letter in parentheses refers to the structure so identified on plates 4 [1] and 5 [1]. Ground photographs of a few of the typical or unusual structures are included as appendix 2 [1] of this report.

50. The west breakwater at Ashtabula Harbor (B), 7,200 feet in length extending in a northeasterly direction is an impermeable structure of rubble mound or timber crib substructure with stone superstructure. A narrow gap at its inner end separates it from the

[1] Not printed.

more permeable rubble mound shore return (A) which is nearly normal to shore and 580 feet in length. Sand trapped by the shore return has formed a wide beach to the west and wind and wave action which has carried sand over or around the inner end of the shore return has been responsible for the formation of the beach to the east. The east breakwater (C), which, with the outer end of the west breakwater forms the arrowhead entrance to Ashtabula Harbor, has a total length of 4,400 feet. Its inner end is approximately 2,400 feet offshore. An inner breakwater (D) protects the ore docks of the New York Central Railroad from waves which enter the harbor through the entrance gap, but has no appreciable effect on shore processes affecting littoral movement of sand.

51. Approximately 1,200 feet of the Lake Shore Park frontage is protected by a concrete sea wall and promenade (E and F). Erosion of the low bluffs has been experienced along the remainder of the park frontage east of the protected area.

52. In 1931, the Cleveland Electric Illuminating Co. completed construction of an intake channel approximately 200 feet wide and extending 1,980 feet into the lake, an outlet canal approximately 150 feet wide and 1,060 feet long, and a rubble mound sea wall protecting the balance of the company owned shore frontage. The rubble mound sea wall (1) commenced at the westerly property limit of the Cleveland Electric Illuminating Co. and extended east approximately 570 feet at an acute angle with the original shore line. Fill was placed behind the sea wall. The west pier (2) of the intake channel is an extension of the rubble mound sea wall. The outer end of the pier, which extends, 1,980 feet into the lake, is curved to form a protected inlet. The east pier (3) of the intake channel is rubble mound construction approximately 1,180 feet long. The outlet canal is formed by two parallel rubble mound walls. The walls were built at an acute angle with the shore line east of the plant. The lakeward wall (4) has a total length of 1,060 feet. The inner wall (5), including a 340-foot shore return at its easterly end, has a total length of 1,455 feet. The triangular area between the original shore line and the inner wall and shore return was backfilled with material taken from the powerhouse site. There was little damage due to wave action noted in this area during a recent field investigation.

53. Approximately 1,500 feet east of the Cleveland Electric Illuminating Co., the Electro Metallurgical Co. constructed a pier (10) to deflect the water discharged from the plant to the east. The inner 66 feet consists of parallel rows of steel sheet piling and is normal to the shore. The outer 107 feet is of cellular steel sheet pile construction and is curved to the east. The pier was completed during the late spring of 1949.

54. The Ohio State Highway Department constructed a sea wall (20) west of the mouth of Whitman Creek to protect State Highway 531 which closely parallels the lake shore at this point. The sea wall consists of interlocking corrugated steel sheet piling driven at about a 45° angle. Stone toe protection has been added to prevent undermining by wave action. Bituminous paving of the top of bank between the piling and the highway was also added. There has been little change along this stretch of shore line since the completion of the sea wall in 1946.

55. At Kingsville-on-the-Lake, a 130-foot concrete groin (25) was built in 1907. Since that time, the groin has impounded a wide sand point and bluff erosion is negligible. At Harrington Point, a system of groins (50–55) and sea walls (52A and 53A) have held a similar wide sand point.

56. The Conneaut water works has been protected by a rubble mound sea wall (85) built approximately 100 feet from the base of the bluff. Shore returns at either end of the sea wall are tied into the bluff. Since the construction of the shore returns and sea wall in 1934, a wide sand beach has formed west of the structure. The bluffs immediately west of the water works have been protected from wave attack due to the increased width of the beach. A stone filled timber crib sea wall (85A) was constructed in 1947 at the base of the bluffs immediately east of the rubble mound sea wall to prevent further erosion of the bluffs in this area. Tile drains running parallel to the top of the bluff and diagonally down the slope collect surface water and seepage and have aided in stabilizing the bluff.

57. Prior to the construction of the shore arm of the west breakwater at Conneaut Harbor, the city of Conneaut built three stone-filled timber crib groins and a concrete groin in an effort to maintain the beach and bluffs at Lake View Park. The westerly groin (89) is now in poor condition and groin (91) is now in ruins. The easterly groin has been incorporated in the construction of the city dock. The concrete groin (90) which was built in 1925 is in good condition. Since the construction of the west breakwater shore arm, the groin system has been ineffective due to the lack of littoral drift within the harbor area.

58. The west breakwater shore arm (92) at Conneaut Harbor extends 1,670 feet normal to the shore. This rubble mound structure, completed in 1935, has interrupted the west to east littoral drift, forming a wide breach to the west. Some of the beach material carried over the shore arm by wind and wave action, has formed a beach east of the structure. The west breakwater (93) built in 1916, is separated from the shore arm by a 100-foot gap. In 1934, the outer end of the breakwater, which was nearly parallel to shore, was removed. The breakwater was extended in 1935 to form the west member of the arrowhead entrance.

59. The east breakwater (94) at Conneaut Harbor is 3,675 feet long. Approximately 1,050 feet of this structure consists of a stone-filled timber crib substructure with a concrete superstructure. This portion of the breakwater was completed in 1907. The breakwater has been extended both landward and lakeward by rubble mound construction, the east member of the arrowhead entrance having been completed in 1935. The east pier (95) 1,008 feet long, was built in 1907. It consists of a stone-filled timber crib substructure and a concrete superstructure. The west pier (96), owned by the Bessemer and Lake Erie Railroad Co., is a concrete capped stone-filled timber crib structure approximately 2,000 feet long.

VI. SHORE LINE AND OFFSHORE CHANGES

60. *Available data.*—Only two complete surveys have been made from which a comparison of the location of the shore line and changes in the offshore depths can be made for the entire study area. These

surveys were made by the United States Lake Survey in 1876 and 1948, the latter in connection with the present study. Comparisons between the 1948 survey and the 1876 survey are subject to considerable doubt because of uncertainties regarding lake stage correction, lack of sufficient common control points, and the lack of detail inherent in the earlier leadline method of sounding.

61. The 1948 hydrographic survey was made with the use of an echo sounder which records a true profile of the lake bottom as the survey boat moves along the profile line. In order to obtain comparable profiles from the 1876 survey, the 1948 profile lines were located on the 1876 chart and profiles were interpolated from the nearest 1876 soundings. Echo sounder records indicate sharply changing depths at places in this area leading to the conclusion that an interpolated profile is unreliable for comparison, and that the only true test of erosion or accretion would be profiles from actual soundings taken on identical lines.

62. In 1934 and 1935, the Buffalo district of the Corps of Engineers made several surveys in conjunction with the construction of the shore arm of the west breakwater at Conneaut Harbor, Ohio. Annual surveys are made in connection with the maintenance dredging of the Federal project areas at Conneaut and Ashtabula Harbors, but these surveys are of insufficient scope to be of material use in this study.

63. Locations of all profile lines are shown on plate 1. However, only 10 of the comparative profiles, shown on plates 2 [1] and 3 [1] are included in this report to illustrate typical conditions throughout the study area.

64. *Shore line changes.*—In 1876, very few soundings were taken in depths less than 5 feet and although the water's edge at the time of survey was located, sufficient inshore data are lacking to permit reducing the entire shore line of the 1948 and the earlier surveys to a common datum necessary for comparison. However, an approximation of the changes in the shore line was obtained by comparing 1948 profiles with the 1876 profiles. The distance between the profile lines varies from approximately 500 feet to 5,050 feet. The average distance between profile lines is approximately 1,660 feet. In some areas, the movement of the shore lines varies greatly within short distances, and in view of the fact that the average distance between profiles is approximately 1,660 feet, the shore line changes indicated at the profile lines may not be representative of the entire stretch of shore between the profile lines.

65. Additional data were obtained in a few locations by comparison of the shore line as found in 1938 aerial photographs, with the corresponding shore line at the same water stage as found in the 1948 profiles. In general, the movement of the shore line at these locations during the 10-year period was too small to be measured from the aerial photographs. However, where changes could be measured, they compared favorably with the average annual rate of movement of the shore line during the 73-year period between hydrographic surveys.

66. Comparative profiles indicate that the rate of recession of the low water datum shore line has been greater west of profile 20 than to the east of that profile. Comparison of the profiles shows that the shore line has moved an average of 100 feet landward between profiles 1 and 14. The maximum landward movement of 235 feet occurred in

[1] Not printed.

the vicinity of profile 1 which is 600 feet east of the Cleveland Electric Illuminating Co. The shore line has moved an average of 220 feet landward between profiles 15 and 20. The most severe recession in the study area occurred in the vicinity of profile 20 where the 1948 low water datum shore line was approximately 290 feet landward of the 1876 low water datum shore line. The bluffs on either side of this area have receded at a somewhat slower rate and a cove approximately 1,400 feet long has resulted under these conditions.

67. There has been a 130-foot lakeward movement of the shore line in the vicinity of profile 21 which is approximately 2,400 feet east of profile 20. Local residents claim that the slight lakeward curvature of the shore line in this area has resulted from the impounding action of groins which are now buried under the sand. The presence of numerous trees at the base and on the slope of the bluffs behind the beach further indicates that this area has been relatively stable for an extended period.

68. The shore line east of profile 20 has remained relatively stable during the period between surveys. The maximum variation in this section of shore line occurred within the limits of Conneaut Township Park. The 1948 shore line receded a distance of 170 feet from the 1876 shore line in the vicinity of profile 33. The accumulation of beach material to the west of the west breakwater shore arm, built in 1935 at Conneaut Harbor, has resulted in the maximum lakeward movement of the shore line within the limits of the study area. Data obtained from a survey made in 1935 show that this area experienced erosion between 1876 and 1935, which resulted in a 110-foot landward movement of the shore line. Comparison of the 1935 and 1948 profiles indicates that material impounded by the west breakwater shore arm caused a 320-foot lakeward movement of the shore line during the 13-year interval.

69. While in general, the recession of the shore line and bluffs at Lake View Park has been gradual due to the protection provided by the Conneaut Harbor breakwaters, a severe storm in 1942 removed approximately 25 feet of the terrace located near the toe of the bluff along the park frontage. Comparative profiles 37 and 38 indicate that the balance of the park frontage has experienced only a moderate landward movement. Comparison of all available data indicates that the park frontage was relatively stable prior to the construction of the west breakwater shore arm, and that the major portion of the erosion occurred after construction of the west breakwater shore arm. Comparative profiles taken between Conneaut Harbor and the Ohio-Pennsylvania State line show only slight changes during the period between surveys.

70. *Offshore changes.*—Available information does not permit an accurate comparison of depth contours. Errors of considerable size between the 1875 and 1948 profiles could easily occur as a result of interpolation from soundings taken on lines about 700 feet apart in the earlier survey. It is, therefore, impossible to determine and describe the offshore depth changes in detail. For the same reason, volumetric computations of erosion and accretion in the offshore, beach, and bluff areas cannot be made, except in special cases where more detailed data are available as described in the following paragraph.

71. *Volumetric computations.*—As stated in paragraph 62, surveys were made in connection with the construction of the shore arm of the west breakwater at Conneaut Harbor. The amount of material accumulated by the west breakwater shore arm was obtained by comparison of the data obtained during the 1935 survey with that obtained during the 1948 survey. An average of approximately 6,000 cubic yards has been accumulated annually in this location during the 13-year period between these surveys. This total does not include the beach material carried over the shore arm by wind and wave action.

VII. PLANS OF IMPROVEMENT

72. *Improvements desired.*—During the preparation of this report, a representative of the Buffalo District of the Corps of Engineers interviewed local officials charged with the administration of public park areas within the limits of the study area, to determine their erosion problems and the need for further development or improvement of public park frontages. Local officials of Conneaut Township Park requested plans for an economical and effective method of protecting the bluffs and enlarging the existing recreational beach along the westerly portion of the park frontage. Lake View Park officials stated that the erosion problem was not serious and no improvements were contemplated at this time. The State of Ohio has requested plans for the protection of privately owned property in the study area, type designs, and approximate cost estimates of typical structures.

73. *General methods of protection.*—In general, erosion due to wave attack at the base of an unprotected bluff may be reduced either by building a beach of suitable profile to prevent direct wave attack on the bluff, by erecting a sea wall capable of resisting wave attack or by providing some form of revetment at the toe of the bluff. There are two methods of building and improving beaches in areas where those provided by natural forces are not of sufficient width and height to protect the bluffs. In areas where the supply of sand transported by littoral currents or furnished directly to the beach by erosion of the bluffs is plentiful, groins may be built to arrest the movement of the sand and accumulate it in a chosen location. In areas where there is a very limited natural supply of sand, beaches may be created by adding sand artifically. If natural forces tend to remove sand from such areas faster than it is restored by natural forces, groins may be used to reduce the rate of removal. These general principles have been considered in the plans of improvement discussed in the following paragraphs.

74. *Analysis of the principal features of the problem.*—The underlying causes of erosion within the study area are the characteristics and behavior of the bluff material. It is easily eroded both by wave attack and by meteoric water flowing over the face of the bluff. Water seepage through the relatively pervious upper stratum causes large sections of the bluff to slough off into the lake where the fine material is dispersed by wave action. The primary cause of erosion is direct wave attack at the base of the unprotected bluffs and its control provides the most serious erosion problem within the study area.

75. As indicated in paragraph 28, little beach material is supplied by natural forces from outside the study area. The amount of suitable

beach material in the bluffs varies widely along the shore frontage of the study area. As additional sections of the shore line are protected, less material will be supplied to the down drift beaches. Groins constructed to build beaches by arresting littoral drift should be designed to hold the minimum amount of sand required for protection of the immediate area and to allow sand in excess of this amount to move down drift. This practice leads to the most economical and equitable use of the limited natural supply of sand.

76. *Conneaut Township Park.*—At the present time, the bluffs in the easterly section of Conneaut Township Park are effectively protected by a wide beach resulting from the impounding of littoral drift by the shore arm of the west breakwater at Conneaut Harbor. It is expected that the unprotected portion of the park frontage will decrease in length as the area of accretion extends to the west. It is assumed that the shore line will move lakeward parallel to the existing shore line of the present area of accretion. Thus the limited supply of natural beach material will be distributed over the entire area of accretion and result in an unnecessarily wide beach adjacent to the breakwater shore arm and a very gradual accumulation of beach material in the area where erosion is now active. It is estimated that the necessary protection for the park frontage now experiencing erosion would be obtained under these conditions in approximately 25 years. A more economical use of the limited supply of beach material would be obtained by concentrating it in an area where erosion is now occurring. This could be accomplished by construction of a groin near the westerly end of the existing beach. After the accumulation of an adequate protecting beach, the bluffs may be graded to a stable slope and sodded. By use of the latter method, it is estimated that the necessary protection would be obtained in only 7 years. The beach impounded by the proposed groin would also extend to the west and provide at least partial protection to the privately owned property adjoining the park.

77. The proposed location and general design features of the proposed groin are shown on plate 7. Since shale is found at or very close to the lake bottom in this area, gravity-type structures must be used. Under present economic conditions, cellular steel sheet pile construction is estimated to be the most economical gravity-type structure at this location. However, another type of gravity structure could be used if found more economical at the time of construction. The total length of the proposed groin is 224 feet. The inner end of the groin should be extended well into the bluff to avoid loss of sand around the inner end. The groin profile consists of a horizontal section 107 feet long with a top elevation of 8 feet above low water datum and a 117-foot long section on a 1 on 20 slope extending lakeward to an elevation of approximately 2 feet above low water datum. It is expected that little of the existing area of accretion west of the west breakwater shore arm will be lost as a result of the interruption of littoral drift by the proposed groin since the sand will be effectively pocketed between the west breakwater shore arm on the east and the proposed groin on the west.

78. *Plans for improvement of private property.*—Since the shore line characteristics differ considerably throughout the study area, five designs for the protection of private property have been developed to meet varying requirements of this particular section of the Ohio shore

line. The choice of the type of improvement is primarily dependent upon the physical characteristics of the particular section to be protected and the intended use of the shore frontage. Conditions favoring the use of each type of protection are discussed as each plan is described. After careful consideration of all conditions at any locality the most advantageous plan should be selected.

79. *Protection by sea walls.*—The lack of an adequate amount of littoral drift along the shore line of the study area, precludes the general use of groins designed to impound littoral drift to provide an adequate beach for protection of the bluffs. The most practical method of shore protection independent of the supply of beach material, is the construction of a revetment or a sea wall to armor the toe of the bluff against further wave attack. The composition of the bluffs and elevation of the shale are determining factors in the consideration of the type of toe protection. The stone revetment shown as plan A, on plate 6, may be used to protect the toe of a bluff in the zone of wave action where the upper slope is stable or can be economically graded to eliminate earth pressure on the proposed revetment. The stone revetment should be founded on the shale and suitably anchored to prevent dislodgement of the toe stone and resultant failure of the structure. It consists of facing stones with an average weight of 4 tons and a minimum weight of 2 tons laid on an 18-inch filter blanket of crushed stone and constructed on a 1 on 2 slope to an elevation of 12 feet above low water datum. This height has been found necessary under similar conditions of exposure and wave action.

80. Plan B, a closed-face metal-crib sea wall, is suitable for use where it is not possible, due to the nature of material in the bluffs, to eliminate lateral pressure. It is constructed with a batter of 1 in 6 on the lakeward face to approximately 8 feet above low water datum. For stability, the footing for the crib posts should be anchored in the underlying shale which is quite close to the surface in this area. The use of the crib-type sea wall is not advisable unless foundation rock is close to the surface. The lower layer of crib-fill must be of sufficient size to prevent loss of fill between the lower member of the crib face and the irregular shale surface. Finer gravel may be used for the balance of the crib fill. Erosion of the lower slope by water thrown over the sea wall during severe storms, may be prevented by paving the slope to an elevation of 12 feet above low water datum. Slope paving consisting of facing stones having a minimum weight of 2,000 pounds should be laid on a filter blanket of crushed stone.

81. A cellular steel sheet pile sea wall has been designed which will be stable under heavy surcharge loads, and which is suitable for use where rock is somewhat deeper than that on which a crib can be economically constructed. General design features for this type of improvement are shown as plan C on plate 6. The top height of the sea wall is 8 feet above low water datum. Slope paving similar to that used in plan B should be added to prevent scour of the toe of slope behind the sea wall. The foundations for plans A, B, and C should be carried to rock or to below the expected depth of scour since wave action can be expected to cause scour at the base of these protective structures and remove any existing beach material in front of it. Scouring action in soft material at the face of a sea wall can be expected to extend to a depth below still water level equal to the wave height.

82. *Protection by narrow beaches and revetment.*—Along the shore line etween Poor Road and the easterly limit of the study area, there is vidence of a moderate amount of littoral drift. The existing beaches revent bluff erosion under mild wave attack. The serious erosion hich occurs only during severe storms may be prevented by construc- on of a revetment at the base of the bluff. However, it will be neces- ary to stabilize or improve the existing beach prior to the construction f the revetment since wave action on the revetment may otherwise esult in the loss of the existing beach and endanger the structure by ndermining. The existing beach can be stabilized and improved by ne construction of short groins. Plan D shown on plate 6 illustrates ne combination of the protective features of a beach, stabilized by roins, and revetment.

83. The revetment is constructed of facing stones having a minimum eight of 2,000 pounds, which are laid on a filter blanket of crushed tone, to an elevation of 10 feet above low water datum. The founda- ion of the revetment should be carried to shale or to at least 2 feet elow low water datum in earth. Precast concrete blocks could be ubstituted for the stone facing.

84. The groin proposed as part of plan D is of cellular steel sheet ile construction. The inner end of the groin has an elevation of 5 eet above low water datum and extends 59 feet lakeward on a 1 on 0 slope to approximately 3 feet above low water datum. Groins of his length should not be spaced over 100 feet apart. Under existing onditions the beach can be expected to accumulate and become tabilized within a short time by natural accretion. Severe erosion f the down drift beaches is unlikely since the proposed low groins ill interrupt only part of the littoral drift and allow the balance to upply necessary nourishment to the down drift beaches.

85. *Protection by high groins and controlled erosion.*—Where the luffs contain a considerable proportion of beach material and no tructures are located so close to the top of the bluff as to necessitate ositive protection against any further recession of the bluff, a less ostly plan using high short groins may be used. This plan consists f short groins extending normal to the shore line and having a mini- num length of 100 feet from the toe of the bluff. Based on the linement of existing impounding areas, it appears that groins of this ength spaced about 200 feet apart would provide a beach wide enough or adequate protection. Under this plan the slope would not be rmored and erosion of the bluff would be permitted to supply material o fill the groin system. The groin system would operate to retard rosion of the beach and the beach might be expected to build up to rotect the toe of the bluff. In order to retain the beach at the toe f the bluff, the inner end of the groins should be above the height eached by the highest waves. It appears that a height of 8 feet bove low water datum would meet this requirement. The top of the roin should parallel the natural slope of the bottom. Adequate rovision must be made against flanking of the groins, initially by xtending the groin into the bluff as far as practicable and later by andward extension of the groins horizontally with a top elevation of 8 feet as the bluff recedes, if necessary. A groin should be constructed at the easterly limit of the area to be protected. This plan and the preceding plan using short groins and toe revetment have an advantage

over the bulkhead and sea wall types of protection where the owne desires a beach at the foot of the bluffs.

86. *Proposed drainage.*—Along the stretches of the shore line wher seepage and runoff are serious contributory factors to the erosio problem, the drainage systems which have been included in all of th plans for the protection of private property, shown on plate 6, will b necessary. Drains should be installed approximately 10 feet lan ward of the top edge of the bluff to collect surface runoff if the natura slope of the upland surface is toward the lake. An open-joint til drain laid in a trench approximately 2 feet deep, back-filled wit crushed stone or gravel, could be provided for this purpose. Pave gutters or drains should be provided to carry the water collected b this drain down the face of the slope to the lake.

VIII. ECONOMIC ANALYSIS

87. *Authority for Federal aid.*—Public Law 727, Seventy-nint Congress, second session states—

* * * That with the purpose of preventing damage to public property an promoting and encouraging the healthful recreation of the people, it is hereb declared to be the policy of the United States to assist in the construction, bu not the maintenance, of works for the improvement and protection against erosio by waves and currents of the shores of the United States that are owned by State municipalities, or other political subdivisions: *Provided*, That the Federal contr but on toward the construction of protective works shall not in any case excee one-third of the total cost * * *.

Since the law does not provide for Federal contribution toward th protection or improvement of privately owned property, an economi analysis to determine the justification of Federal participation i required only where protection and improvement of public propert is involved. However, if the improvement considered most satis factory for public property cannot be accomplished without als including the adjoining private property, the latter must also b included in the economic analysis.

88. The only publicly owned lake front properties in the study are are a short section of highway right-of-way at Whitman Creek, th city of Conneaut waterworks, Conneaut Township Park, and Lak View Park. Additional protection is considered necessary only a Conneaut Township Park. The erosion is not considered serious a Lake View Park and the shore frontages at Whitman Creek an Conneaut waterworks have been protected by local interests an maintenance of these existing structures will provide all the protectio needed at this time.

89. *First cost.*—The total first cost for the considered plan of pro tection and improvement at Conneaut Township Park has bee estimated to be $22,600. This total includes the costs for plant labor, materials, engineering services for design, preparation of plans and specifications, supervision, inspection, and overhead. Detailed estimates are given in appendix 5 of this report.

90. *Estimate of benefits.*—The principal benefits that would result from the proposed improvement consist of direct damages prevented and recreational benefits. The publicly owned upland property will continue to be used for park purposes and its earning power will not materially increase if protected from erosion. The recreational benefits which have been evaluated are due to providing increased

beach frontage in a more desirable location sooner than it would be provided under existing conditions.

91. It is estimated that the protection of the shore line and the improvement of the beach area which would be effected by the proposed structures within 7 years would occur under existing conditions without further improvement within 25 years. The benefits due to the proposed improvement would be realized because of more rapid reduction in damages to the public park property and to the adjoining private property. Additional public benefits would be realized by the earlier development of desirable beach area. The average annual benefits evaluated in the following paragraphs represent only the difference between the benefits realized from the proposed improvements and those which would occur under existing conditions.

92. The direct damage prevented at Conneaut Township Park and adjacent frontage by the proposed improvement is the difference between the value of the property that would be lost by erosion if no further protection is provided, and that which would be lost if the proposed plan is adopted. The direct damage to public property prevented by the proposed improvement is estimated at $245 annually. The damage prevented to private property is estimated to be $215 annually.

93. Recreational benefits have been evaluated by what is considered a reasonable estimate of the increased use of beaches assuming a value of $0.25 per person for the number of persons likely to use the proposed beach area. A further explanation of the methods used in computing direct damages and recreational benefits is given in appendix 5 of this report. The total annual benefits over a 25-year period are $1,540. This total includes $245 per year for prevention of direct damages to public property, $215 per year for prevention of direct damage to private property and $1,080 per year for public recreational benefits.

94. *Allocation of costs.*—The Federal policy for the expenditure of Federal funds to construct shore protection structures and other related works for the improvement and protection of shores owned by States, municipalities and other political subdivisions, is set forth in Public Law 727, Seventy-ninth Congress, second session, approved August 13, 1946. The Federal share of the cost of the project is the percentage of the total interest represented by the Federal interest plus not to exceed one-third the total cost of the construction of works for the improvement and protection of shores owned by States, municipalities, or other political subdivisions excluding costs of necessary lands, easements, and rights-of-way. The non-Federal public share of the cost is determined as a percentage of the total interest represented by the non-Federal public interests, less that portion of the cost to be contributed by the Federal Government under the provisions of Public Law 727, Seventy-ninth Congress, second session. The remaining share of the cost is determined as the percentage of the total interest represented by the private interest.

95. There is no direct Federal interest in the considered improvement at Conneaut Township Park since there is no federally-owned property requiring protection. However, the park is publicly owned and benefits derived from its improvement are public benefits. In addition to the public benefits there are also benefits to adjoining private property. The full one-third contribution toward the protection and improvement of public property is considered justified,

provided the annual public benefits are equal to, or greater than, the total annual costs of the improvements. If the estimated annual public benefits are less than the estimated annual costs, the amount of Federal participation should be proportionately reduced. Any necessary alterations to utilities are considered the responsibility of the owners. The allocation of first costs, assuming for purposes of computation that the full one-third contribution is possible, would be $7,500 for Federal interests and $15,100 for non-Federal interests. Using interest rates of 3 percent for Federal costs, 3½ percent for non-Federal costs, amortization over a period of 25 years, and estimated maintenance costs of $80 annually, the total estimated annual cost of the proposed improvement, based on the assumed or trial allocation of costs is $1,425. The total annual public benefits which amount to $1,325 are less than the trial determination of annual costs and in view of the policy above outlined, the Federal participation should be proportionately reduced to approximately 93 percent of the maximum legal one-third participation. On this basis the Federal participation would amount to 31 percent of the total first cost or $7,000.

96. *Annual costs.*—The annual carrying charges for the proposed plan of improvement at Conneaut Township Park are based on interest rates of 3 percent for Federal costs and 3½ percent for non-Federal costs and amortization over a period of 25 years which is considered the useful life of the improvement, because no benefits are anticipated after that period. Interest during construction has not been included since the construction period for the proposed improvement would not extend into more than one season. The estimated annual costs are given in table 5 below:

TABLE 5.—*Annual costs*

Item	First cost	Interest	Amortization	Maintenance	Total
Federal	$7,000	$210	$190		$400
Non-Federal	15,600	545	400	$80	1,025
Total annual costs					1,425

97. *Benefits-costs ratio.*—The total estimated annual benefits are $1,540. The total estimated annual costs are $1,425 giving a benefits-costs ratio of 1.1:1. The considered plan of improvement will protect the bluffs along the westerly section of the shore frontage of Conneaut Township Park and adjoining private property, and provide additional facilities for the encouragement of healthful recreation of the people in the study area. It is recognized that the favorable benefits-costs ratio is due in part to recreational benefits which have been evaluated. It is further recognized that the monetary value of these benefits cannot be accurately determined because of the intangible health benefits involved. An attempt has been made to arrive at a reasonable value of recreational benefits based on the anticipated increase in patronage and a conservative value per person.

98. *Estimates of cost for protection of private property.*—Five plans of improvement have been designed to meet the various requirements of private property owners within the study area. Since it is beyond the scope of this report to prepare cost estimates for the protection

of specific stretches of privately owned shore line, cost estimates for the various plans have been prepared by assuming conditions as near typical as possible. Plan A consists of construction of a stone revetment at the base of a stabilized slope. The metal crib proposed as plan B may be used under similar conditions or where lateral pressures cannot be entirely eliminated. Additional protection is provided by armoring the slope above the top of the crib for the latter plan. Plan C provides protection against wave attack and heavy surcharge loads by construction of a cellular steel sheet pile sea wall and slope paving. Plan D combines the protection provided by a narrow beach maintained by groins, and a stone revetment. Plan E consists of high short groins to control erosion of the bluff and hold the beach building materials derived from such erosion within the immediate area to build a protective beach. The cost of grading and drainage has been included in each of the plans proposed for the protection of private property except plan E. The conditions under which these plans are most effective are discussed in paragraphs 79 through 86. The cost of protecting 100 to 200 linear feet of shore line has been estimated in each case. Since mobilization and demobilization costs are independent of the lengths of shore line protected, some savings will be realized where long stretches of shore line are improved in one operation. Detailed estimates of first costs for the considered plans of improvement based on current prices and prevailing union wage rates and practices, are given in appendix 5 of this report. A summary of the estimated first costs is given in table 6 below.

TABLE 6.—*Summary of estimated first costs (private property)*

Plan of improvement	Length of shore line protected, feet	Total first cost [1]	Cost per linear foot of shore line protected [1]
Plan A, stone revetment and slope treatment	100	$13,100	$131
Plan B, metal-crib sea wall and slope treatment	100	10,900	109
Plan C, cellular steel sheet pile sea wall and slope treatment	100	19,300	193
Plan D, short cellular steel pile groins, stone revetment, and slope treatment	100	11,600	116
Plan E, high groins and controlled erosion	200	8,400	42

[1] Exclusive of planning, inspection, and supervision.

99. *Coordination with other agencies.*—During the progress of the study, conferences have been held between representatives of the Corps of Engineers and the cooperating agency. The views and suggestions of representatives of the cooperating agency expressed orally and in writing have been given careful consideration in the preparation of this report. The attention of the cooperating agency has been called to the fact that Federal participation in the work would require approval by the Chief of Engineers of detailed plans and specifications and arrangements for the prosecution of the project prior to commencement. Attention has also been called to the fact that Federal participation would be contingent upon the State of Ohio or appropriate local authority agreeing to be responsible for:

(*a*) Maintenance and repair during the useful life of the project as may be required to serve the intended purpose.

(*b*) Provision of all necessary lands, easements, and rights-of-way.

(*c*) Claims for damage either before, during, or after prosecution of the work.

(*d*) Control of pollution to assure that pollution injurious to the health of bathers will not be permitted.

(*e*) Maintaining public ownership of improved publicly owned shore and its administration for public use only.

IX. DISCUSSION

100. *General plans of improvement.*—Investigation of the Ohio shore line of Lake Erie indicates that the predominant littoral currents move material from west to east along the shore frontage of the study area. Little of the beach material derived from erosion of the updrift shore can be furnished beaches in the study area since the breakwaters at Ashtabula Harbor intercept the littoral drift from the west. Therefore the beach areas under consideration are dependent upon beach material supplied from erosion of bluffs within the study area. The amount of beach material in actively eroding bluffs in the study area varies considerably. West of Poor Road in Kingsville Township, an average of only 13 percent of the bluff material sampled was found to be suitable for beach building. The extremely narrow beaches and the ensuing bluff erosion due to wave attack reflect the lack of beach material in this area. Approximately 27 percent of the material in the bluffs between Poor Road and the easterly limit of the study area was found suitable for beach building. The bluffs along this section of shore line are generally fronted by beaches whose width is adequate to prevent erosion during low lake stages.

101. Five plans for the protection of private property were prepared with a view of providing alternative types of shore protection to suit both the shore line characteristics and the desired utilization of the shore frontage by the private property owner. These methods of protection and improvement have been described in detail in paragraphs 79 through 86.

102. Due to the lack of beaches on long sections of the shore frontage of the study area, three sea wall and revetment designs for private property have been prepared to provide immediate stabilization of the bluffs independent of the supply of beach material and a plan is proposed for controlled erosion of the bluffs using high groins to collect and hold the beach building material at the toe of the bluff to form a protective beach. Plan A has been designed to protect the bluffs by armoring the toe of the slopes. The armoring consists of heavy facing stones laid on a filter blanket of crushed stone whch prevents leaching of the fine silt and clay through the large openings between facing blocks on the lakeward face of the revetment. This plan of protection may be used only in areas where the existing slopes are stable or can be economically graded to such a slope as will not require lateral support from the toe protection. Plan B is an alternative plan which may be used under similar conditions where some lateral support is required. It consists of a metal-crib sea wall and slope paving. Plan C has been designed for the remaining portion of this shore line where the amount of beach building material is negligible and it is not practical to eliminate or reduce earth pressure on the proposed structure by trimming the entire bluff to a stable slope. This plan

onsists of a cellular steel sheet pile sea wall and slope paving similar
o that used in plan B. It is also more suitable than plan B where the
epth to rock is such that foundations for plan B would be under
veral feet of water.

103. Plans A, B, and C described above are alternative plans for
complishing immediate stabilization of the toe of the bluff. Founda-
ons for this type of improvement should be placed on rock or below
ne depth of scour that is anticipated. It is characteristic of this type
improvement that wave action can be expected to remove any
mblance of a beach which may exist in front of the structure at
ne time it is built. This may be advantageous for the property
wner who desires to develop his shore frontage for use of small boats
light draft. No damage to the adjoining shore line is expected
o result from the use of these methods of bluff protection. On the
ther hand, unless the two ends of the sea wall or revetment are tied
to well-stabilized sections of shore line, it will be difficult to
revent flanking of the ends. If the shore line on either side of the
rotected section recedes, it will be necessary to keep the ends of the
a wall tied into the bluff by shore returns. The estimated first cost
r plan A is $131 per foot of frontage protected; for plan B, $109;
nd for plan C, $193. While plan B is the most economical under
nditions assumed for estimating, all three plans should be thoroughly
vestigated since one of the other plans may prove to be the most
onomical under local construction conditions and costs.

104. Plan D combines the protective features of a beach and armor-
g the toe of the bluffs. It is considered to be the most economical
an of protection for the portion of the shore line east of Poor Road
North Kingsville Village. Its design is based on the fundamental
ncept that the beach will provide the principal protection from wave
tion at the toe of the bluff at all times. The armoring of the toe of
ne bluff is designed to resist wave attack during severe storms when
aves, which will have expended a large part of their energy traversing
ne beach area, may reach the bluff. The beach, which can be built
o and maintained by relatively short groins, will prevent under-
tting at the toe of the revetment and consequently the foundation
the latter need not be carried as deep as for plans A, B, or C.
his plan should be used by the property owner who desires a bathing
each as well as shore protection. The estimated cost for plan D is
16 per front of frontage protected.

105. Plan E, which utilizes material eroded from a bluff to build a
each at its toe is limited in application to sections of bluff which
ntain a high percentage of sand and gravel. Relatively high short
oins are used to prevent removal of the beach material by littoral
urrents. Its use is also limited to locations where some further
osion can be permitted without endangering structures at the top
the bluff. As in the case of plan D, this plan has the avdantage of
roviding a bathing beach as well as protection for the bluff.

106. It is beyond the scope of this report to prepare a detailed plan
improvement for the individual pieces of privately owned property.
he typical plans proposed for use under the given conditions are
nsidered to be the best over-all plans. However, in any application
these plans the local conditions should be given full consideration.
he typical structures in the proposed plans are designed for an antic-
ated life of 50 years. Other materials may be used in the construc-

tion if found more economical under local conditions. The effectiv ness of the proposed structures depends upon their height, lengt and profile. The choice of material affects only the durability.

107. *Conneaut Township Park.*—It has been determined tha Conneaut Township Park is the only publicly owned shore frontag requiring further protection at this time. Bluff erosion is now occu ring along the westerly 680 feet of park frontage. The most econom cal and effective method of preventing wave attack and increasin the usable recreational beach area is to construct a groin to concen trate the major portion of the littoral drift along the westerly par frontage that is now experiencing erosion. General design feature of the proposed groin are discussed in paragraph 77 and shown o plate 7. It is expected that little of the existing beach area downdri of the proposed groin will be lost since the beach material will b pocketed between the proposed groin and the Conneaut Harbor wes breakwater shore arm. The first cost of the proposed structure ha been estimated to be $22,600. Estimated annual costs are $1,42 Estimated annual benefits are $1,540 giving a favorable benefits-cos ratio of 1.1. Although the groin is designed primarily for the prote tion and improvement of the park property, benefits to private pro erty estimated at $215 annually are also included in the above tot benefits.

X. CONCLUSIONS

108. *Conneaut Township Park.*—It is concluded that Conneau Township Park is the only publicly owned section of shore line whe additional protection or improvement is needed at this time. Th plan of improvement considered best suited to the needs and resourc of the local officials is the construction of a cellular steel sheet pi groin at the location shown on plate 7. Under the proposed plan improvement the rate of erosion will gradually decrease as the bea is built up for protection and recreational use. It is estimated tha full protection from wave attack on the park property and adjoinin private property will be secured in approximately 7 years. The est mated first cost of the improvement is $22,600. Annual costs a estimated at $1,425 and annual benefits at $1,540 giving a benefit costs ratio of 1.1. It is therefore considered advisable for the Feder Government to adopt a project for the improvement of Conneau Township Park. Federal participation to the amount of $7,000 in th first cost of the proposed plan of improvement, as determined i paragraph 95, is considered justified.

109. *Private property.*—General plans for five types of improvemen considered suitable for the protection and improvement of stretch of privately owned property having various shore line characteristi have been prepared and are shown on plate 6. The adoption of a pla best suited to each locality and for the purpose intended as discusse in paragraphs 79 through 86 is considered advisable. No Feder participation in the cost of protection or improvement of privat property is authorized under existing laws.

XI. RECOMMENDATIONS

110. It is recommended that:

(*a*) The State of Ohio or appropriate local authority adopt the plan f improvement for Conneaut Township Park consisting of the con- truction of a groin as described in paragraphs 76 and 77 and shown n plate 7.

(*b*) A project be adopted by the United States authorizing Federal articipation to the extent of 31 percent of the first cost of the pro- osed improvement at Conneaut Township Park at a Federal cost ow estimated at $7,000.

(*c*) Federal participation in the proposed plan of improvement shall e contingent upon:

1. Approval by the Chief of Engineers of the detailed plans and specifications and arrangements for the prosecution of the project, prior to commencement of work.

2. Agreement by the State of Ohio or appropriate local authority that it will be responsible for such maintenance and repair as may be necessary during the useful life of the project to serve the intended purpose.

3. Provision by the State of Ohio or the appropriate local authority of all lands, easements, and rights-of-way and release of the Federal Government from all claims for damages either before, during, or after prosecution of the work.

4. Rigid control and abatement of any possible pollution in the beach area or adjacent areas to the extent necessary to safeguard the health of the bathers.

5. Assurances on the part of the State of Ohio or appropriate local authority that the public ownership and administration of Conneaut Township Park for public use will be maintained.

111. It is also recommended that owners of private property adopt ne of the proposed plans of improvement best suited to the physical haracteristics and the desired utilization of their shore-front property. Continuous sections of the shore line should be protected wherever he cost of protection can be justified by the reduction of direct dam- ges and by the intangible benefits due to the increased security and njoyment in the use of lake-front property.

EDWARD M. WRIGHT,
Major, Corps of Engineers, Acting District Engineer.

[First endorsement]

OFFICE OF THE DIVISION ENGINEER,
GREAT LAKES DIVISION,
CORPS OF ENGINEERS,
Chicago 15, Ill., August 31, 1950.

To: The Chief of Engineers, United States Army, Washington 25, D. C.

I concur in the conclusions and recommendations of the district ngineer.

JOHN R. HARDIN,
Colonel, Corps of Engineers,
Division Engineer.

APPENDIX 5

Estimates of Benefits and Costs

ESTIMATES OF BENEFITS

1. *General.*—The principal benefits that would be derived from tn considered plan of improvement at Conneaut Township Park ar direct damages prevented and recreational benefits due to the result ing beach improvement. It is estimated that the protection of th shore line and the improvement of the beach area, which would b effected by the proposed structure within 7 years, would occur withou any further improvement within 25 years.

2. Under existing conditions further accretion to the west of th west breakwater shore arm will result in a wider beach with only gradual westward extension of the beach frontage. It is estimate that at the rate of accretion which has existed since 1935 when th west breakwater shore arm was constructed, it would require approxi mately 25 years to extend the beach along the entire park frontage an 600 feet of private frontage to the west. Any further increase in th width of the existing 350-foot wide beach adjacent to the breakwate is of no value for recreational use and is not necessary for protectio against erosion. The proposed plan of improvement would provid rapid extension of the beach frontage west of the proposed groin an it is estimated that within 7 years a beach from 120 feet to 210 fee wide would be formed along the park frontage, and a somewhat nar rower beach would form to the west. These widths should be ade quate for protection against further erosion of the bluff.

3. *Direct damages prevented.*—Comparison of profiles and aeria photographs indicates that the recession of the unprotected bluff along the Conneaut Township Park frontage and approximately 60 feet of private property to the west amounts to an average of approxi mately 2.5 feet per year. The length of park frontage experiencin erosion has been gradually reduced as the area of accretion west o the west breakwater shore arm extends westward. At the presen time approximately 680 feet of the park frontage is unprotected fro wave attack which results in a yearly loss of approximately 1,70 square feet. Park officials report that the value of lake-front propert in this area is approximately $0.40 per square foot. At the presen rate of erosion, the annual damages to the park property amount t approximately $680 per year. On the same basis, damages to th private property amount to $600 annually. The latter estimate i considered to be conservative since the private property has bee improved for residential purposes.

4. *Recreational benefits.*—The recreational benefits derived from th proposed improvement result from a more desirable distribution of th supply of beach material entering the park limits. Under the influ ence of the proposed groin, beach material that is now deposited alon the frontage of the existing area of accretion and causing a superfluou increase in the width of the area of accretion, would be distributed ove

the westerly 680 feet of park frontage and the adjoining private frontage. During low lake stages there is a very narrow beach in this area, and a wider beach is very desirable for protection of the bluff and for use as a bathing beach.

5. No records of park attendance have been kept but park officials report that the existing beach is overcrowded on peak days. They are of the opinion that an increased beach area would be utilized during periods of peak attendance. There are 30 such peak days in an average year considering Saturdays, Sundays, and holidays between June 1 and Labor Day. Allowing 6 days for bad weather there are 24 days of peak attendance in an average year. Existing beach areas are considered adequate to provide for patronage on other days.

6. In order to arrive at a reasonable value of the recreational benefit for an individual for the use of a bathing beach, it has been assumed that it would be at least equal to the charge made for the use of privately owned beaches. Very few of the privately owned beaches in the study area are open to the public and the only bathing beach open to the public without charge is at Conneaut Township Park. In other localities on Lake Erie, the usual charge for parking and the use of private beaches varies from $0.50 to $2 per car. Assuming an average fee of $1 per car and an average of four persons per car, the charge per person is $0.25. It is estimated that on peak days 500 persons in excess of the present capacity would utilize the additional beach area. On this basis the recreational benefits due to the proposed improvement have been estimated to be approximately $3,000 annually.

7. *Total benefits.*—Under the proposed plan the total public benefits would increase from zero to $3,680 annually during the first 7 years, and remain constant thereafter. Over a 25-year period, the total public benefits would amount to $79,120. The nonpublic benefits would increase from zero to $600 annually during the first 7 years and remain constant thereafter and amount to $12,900 in 25 years. The total benefits in 25 years under the proposed plan would amount to $92,020. Under existing conditions, without further improvement, the public benefits would increase from zero to $3,680 in 25 years, amounting to $46,000. The nonpublic benefits would increase from zero to $600 in 25 years, amounting to $7,500. The total benefits, without improvement, would thus amount to $53,500. The difference between the benefits under the proposed plan of improvement and those which will be realized under existing conditions is $38,520, which is the benefit directly attributable to the improvement. The average annual benefits due to the improvement are $1,540, of which $1,325 are public benefits and $215 are private benefits. The above analysis is summarized in the following table:

TABLE 1.—*Analysis of benefits*

Item	Public	Private	Total
Benefits following improvement	$79,120	$12,900	$92,020
Benefits under existing conditions	46,000	7,500	53,500
Net benefits due to improvement	33,120	5,400	38,520
Average annual net benefits for 25-year period	1,325	215	1,540

8. *Direct costs.*—The estimated direct costs of the various plans of improvement based on current cost levels which take into consideration the existing union wage rates and practices, are shown in detail in table 2 below. The cost of an access road has been included wherever a temporary construction road must be built to provide means of moving construction equipment from the top of the high bluffs to the beach area. The estimated direct cost of the plans shown in table 2 below are exclusive of the cost for engineering, inspection and overhead.

TABLE 2.—*Estimated direct costs*

CONNEAUT TOWNSHIP PARK

Item	Quantity	Unit	Unit cost	Subitem cost	Item cost
New groin:					
Steel sheet pile	116,300	Pound	$0.11	$12,793	
Gravel fill	400	Cubic yard	6.65	2,660	
Concrete	30	do	28.60	858	
Excavation	25	do	2.40	60	$16,371
Contingencies					1,729
Total direct cost, Conneaut Township Park.					18,100

PRIVATE PROPERTY

Plan A. 100 feet of slope revetment and slope treatment:					
Access road		Lump sum			$500
Excavation and grading	1,250	Cubic yard	$1.00	$1,250	
Gravel filter	150	do	6.15	922	
Derrick stone	450	Ton	14.50	6,525	
Trench excavation	50	Cubic yard	8.50	425	
Gravel fill—trenches	30	do	6.40	192	
Tile pipe—drains	335	Linear foot	2.75	921	
Seeding	0.25	Acre	600.00	150	10,385
Contingencies					2,215
Total direct cost, plan A					13,100
Plan B. 100 feet of metal-crib sea wall and slope treatment:					
Access road		Lump sum			500
Excavation and grading	1,150	Cubic yard	1.00	1,150	
Gravel filter	50	do	6.15	308	
Derrick stone	95	Ton	14.50	1,378	
Cribbing	930	Square foot face	3.00	2,790	
Trench excavation	50	Cubic yard	8.50	425	
Gravel fill—trenches	30	do	6.40	192	
Tile pipe—drains	335	Linear foot	2.75	921	
Crib fill—gravel	200	Cubic yard	6.40	1,280	
Seeding	0.25	Acre	600.00	150	8,594
Contingencies					1,806
Total direct cost, plan B					10,900
Plan C. 100 feet of cellular sea wall and slope treatment:					
Access road		Lump sum			500
Steel sheet piling	75,100	Pound	0.11	8,261	
Gravel fill—cells	215	Cubic yard	6.40	1,376	
Gravel filter	70	do	6.15	430	
Excavation and grading	875	do	1.00	875	
Trench excavation	45	do	8.50	382	
Tile pipe—drains	350	Linear foot	2.75	962	
Gravel fill—trenches	30	Cubic yard	6.40	192	
Concrete cap	25	do	31.00	775	
Derrick stone	150	Ton	14.50	2,175	
Seeding	0.25	Acre	600.00	150	15,578
Contingencies					3,222
Total direct costs, plan C					19,300

TABLE 2.—*Estimated direct costs*—Continued

PRIVATE PROPERTY—Continued

Item	Quantity	Unit	Unit cost	Subitem cost	Item cost
Plan D. 100 feet of slope revetment, low groin, and slope treatment:					
Access road		Lump sum			$500
Steel sheet piling	20,500	Pound	$0.11	$2,255	
Concrete cap	6	Cubic yard	31.00	186	
Gravel fill—cells	36	do	6.40	230	
Excavation and grading	1,230	do	1.00	1,230	
Gravel filter	80	do	6.15	492	
Derrick stone	215	Ton	14.50	3,117	
Trench excavation	50	Cubic yard	8.50	425	
Gravel fill—trenches	30	do	6.40	192	
Tile pipe—drains	335	Linear foot	2.75	921	
Seeding	0.22	Acre	600.00	130	
Contingencies					9,178
					1,922
Total direct costs, plan D					11,600
Plan E. Protection of 200 feet of shore line with high groins:					
Access road		Lump sum			500
Excavation	30	Cubic yard	3.30	99	
Steel sheet piling	53,430	Pound	.11	5,877	
Gravel fill	60	Cubic yard	6.40	384	
Concrete cap	9	do	31.00	279	
Contingencies					6,600
					1,300
Total direct costs, plan E					8,400

9. *First costs for Conneaut Township Park.*—Estimates of first costs are based on the assumption that the costs will be the same whether done by the Corps of Engineers or the cooperating agency. The total direct costs for plant, labor, materials, and contingencies are $18,100. Other costs which include engineering services for design, preparation of plans and specifications, surveys, supervision, inspection, and overhead, are $4,500. The total first costs for the project at Conneaut Township Park are $22,600.

CORPS OF ENGINEERS

U.S. ARMY

LAKE ERIE

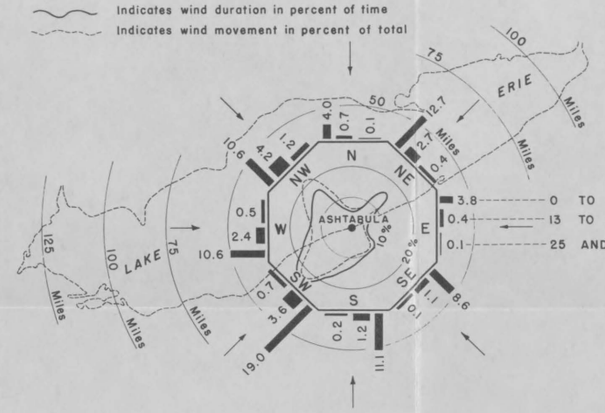
PAINESVILLE TWP. PARK
GENEVA TWP. PARK
SAYBROOK TWP. PARK
WALNUT PARK
PERRY TWP. PARK
N. PERRY PARK
MADISON TWP. PARK
PROPOSED FAIRPORT STATE PARK
WHITE CITY PARK
EDGEWATER PARK
LAKEVIEW PARK
MENTOR TWP. PARK
HUNTINGTON PARK
PROPOSED BEAVER CREEK STATE PARK
CENTURY PARK
CEDAR POINT
CITIES OF CLEVELAND AND LAKEWOOD
V-X
III-VII-XII
IX
XI
XIV
VIII
VI

CONNEAUT
ASHTABULA
GENEVA-ON-THE-LAKE
N. PERRY
GENEVA
MADISON
JEFFERSON
FAIRPORT
PAINESVILLE
MENTOR
WILLOUGHBY
CHARDON
ANDOVER
ORWELL
ROCKY RIVER
AVON LAKE
BAY VILLAGE
LORAIN
SANDUSKY
HURON
VERMILION
ELYRIA
BEDFORD
MILAN
NORWALK
WELLINGTON
MEDINA
LODI
AKRON
HUDSON
GARRETTSVILLE
WARREN
RAVENNA
SAVANNAH
SHELBY

ASHTABULA
GEAUGA
TRUMBULL
PENNSYLVANIA
CUYAHOGA
ERIE
LORAIN
HURON
MEDINA
SUMMIT
PORTAGE
ASHLAND
RICHLAND

LOCALITY MAP
5 0 5 10
SCALE OF MILES

LEGEND
Indicates wind duration in percent of time
Indicates wind movement in percent of total



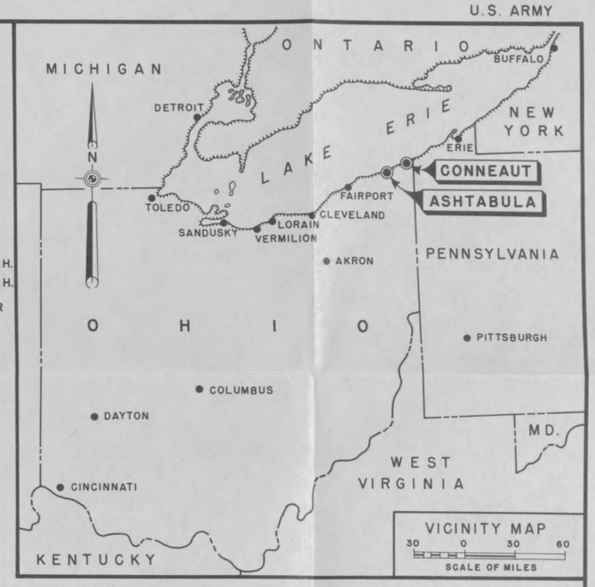
3.8 ---------- 0 TO 12 M.P.H.
0.4 ---------- 13 TO 24 M.P.H.
0.1 ---------- 25 AND OVER

WIND DIAGRAM FOR ASHTABULA, OHIO

NOTES

Figures at end of bars indicate average yearly percentage of occurrence of wind in the direction and intensity shown for the period of Jan. 1, 1937 to Dec. 31, 1948 exclusive of 1944.

Wind data based on records of the U. S. Coast Guard at Ashtabula, Ohio.



LEGEND
----INDICATES PROBINGS
----INDICATES BLUFF SAMPLES
----INDICATES BEACH SAMPLES

LIMITS OF STUDY AREA ..... APPENDICES V & X

APPENDICES III-VII-XII

LAKE SHORE PARK

CONNEAUT TOWNSHIP PARK

LAKE VIEW PARK

CITY OF ASHTABULA

ASHTABULA RIVER

CITY OF CONNEAUT

TURKEY CREEK

LAKEVILLE VILLAGE

OHIO STATE LINE

PENNSYLVANIA

ASHTABULA COUNTY

KINGSVILLE TOWNSHIP

LAKEVILLE VILLAGE

ASHTABULA TWP.

KINGSVILLE TWP.

KINGSVILLE-ON-THE-LAKE

LAKE AVE.

LAKE ROAD

HARMON RD.

POOR RD.

HARRINGTON POINT

WHITNEY RD.

LABOUNTY RD.

RUSSEL RD.

WHITMAN CREEK

CONNEAUT RIVER

U.S. 20

NEW YORK CENTRAL R. R.

NEW YORK CHICAGO & ST. LOUIS R. R.

SCALE IN FEET
3000 0 3000 6000

LEGEND

1949 OFFSHORE DEPTH CONTOURS
6 FOOT DEPTH
12 FOOT DEPTH
18 FOOT DEPTH
24 FOOT DEPTH

(5)—INDICATES PROFILE LINE AND NUMBER
APPENDICES ARE INDICATED THUS— V - X

ALL CONTOURS ARE REFERRED TO LOW WATER DATUM ELEVATION 570.5 FEET ABOVE MEAN TIDE AT NEW YORK CITY.

COOPERATIVE BEACH EROSION STUDY IN ASHTABULA AND KINGSVILLE TOWNSHIPS AND LAKEVILLE VILLAGE
STATE OF OHIO
APPENDICES · V & X · ASHTABULA COUNTY
GENERAL PLAN

IN 7 SHEETS | SHEET NO. 1 | SCALE AS SHOWN
BUFFALO, N.Y. DISTRICT | JULY, 14, 1950

SUBMITTED: Joseph H. Wisnicki, CHIEF, PROJECT BRANCH
RECOMMENDED: S. Ellet, CHIEF, ENGINEERING DIVISION
APPROVED: Frank H. Jamey, COL., CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED AUG. 2, 1950

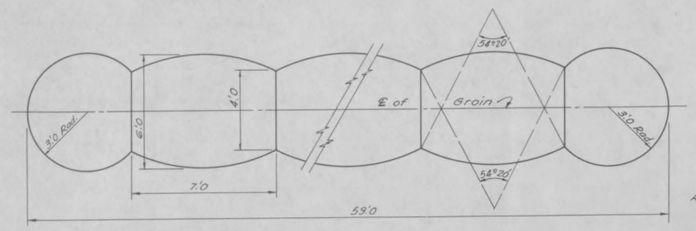
DRAWN R.D.P. TRACED R.D.P. CHECKED G.H. FILE NO.

PLATE I

95139 O - 52 (fols. text) No. 1

CORPS OF ENGINEERS

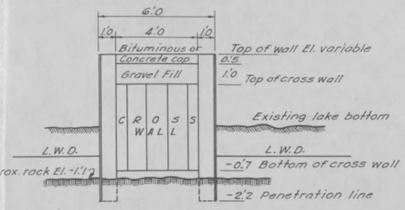
U. S. ARMY



PLAN OF CELLULAR STEEL SHEET PILE GROIN

SCALE OF FEET

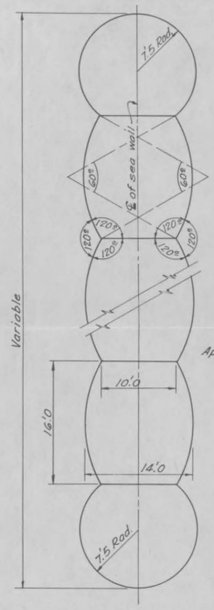
3 0 3 6



TYPICAL CROSS SECTION

SCALE OF FEET

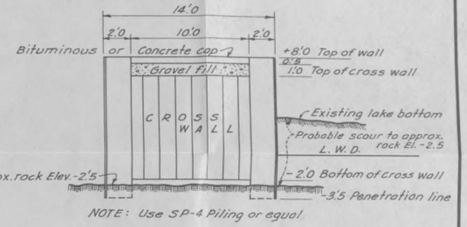
3 0 3 6



PLAN

SCALE OF FEET

8 0 8 16

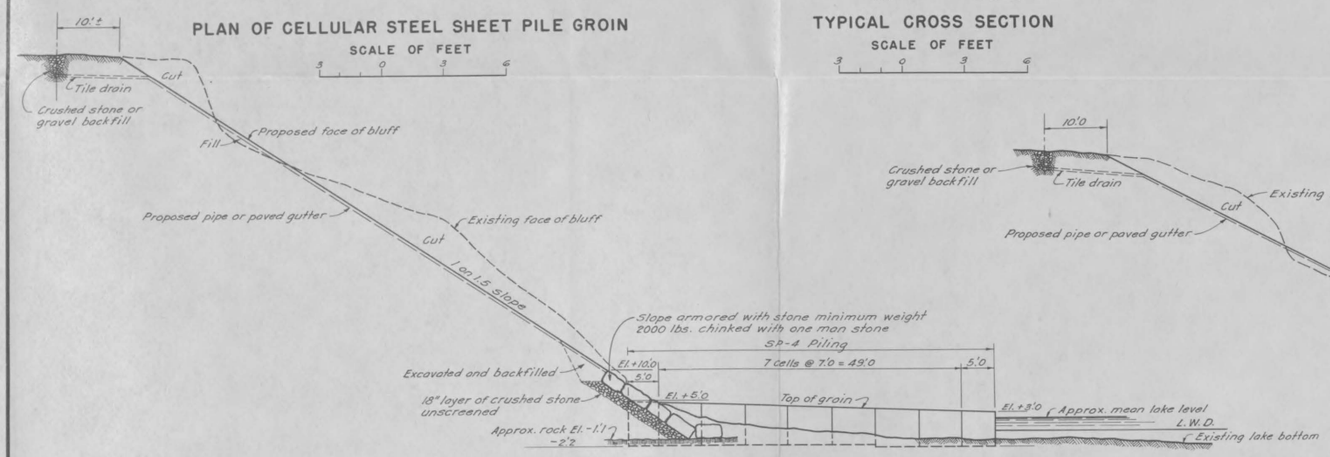


NOTE: Use SP-4 Piling or equal.

TYPICAL CROSS SECTION

SCALE OF FEET

5 0 5 10

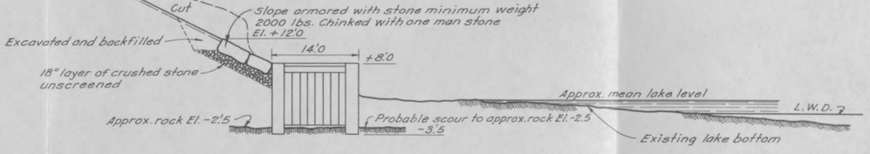


PLAN D

TYPICAL PROFILE OF ARMORED SLOPE AND SHORT GROINS

SCALE OF FEET

10 5 0 10 20

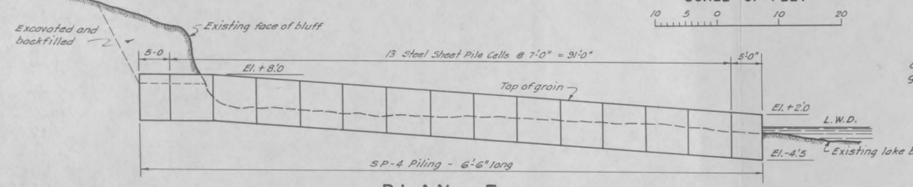


PLAN C

TYPICAL PROFILE OF CELLULAR STEEL SHEET PILE SEA WALL WITH ARMORED SLOPE

SCALE OF FEET

10 5 0 10 20

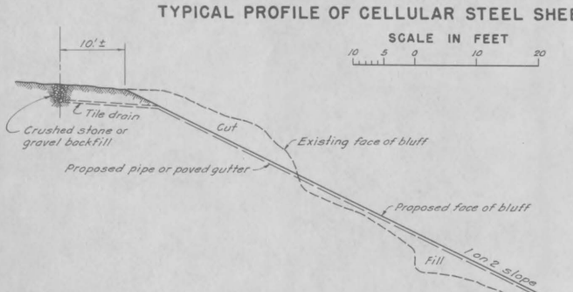


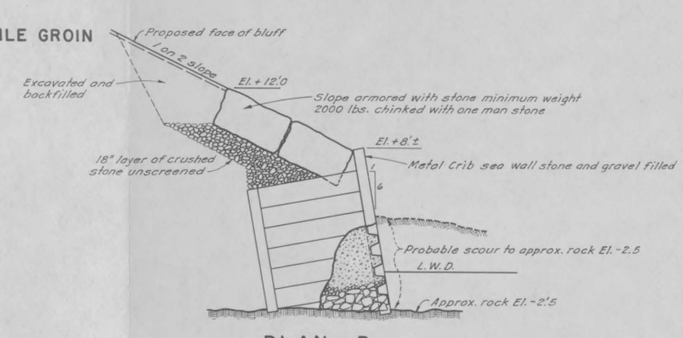
PLAN — E

TYPICAL PROFILE OF CELLULAR STEEL SHEET PILE GROIN

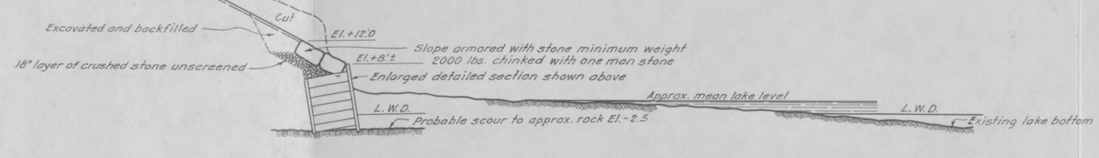
SCALE IN FEET

10 5 0 10 20





PLAN B



PLAN A

TYPICAL PROFILE OF BLUFF REVETMENT

SCALE OF FEET

10 5 0 10 20

PLAN B

TYPICAL PROFILE OF METAL-CRIB SEA WALL WITH ARMORED SLOPE

SCALE OF FEET

10 5 0 10 20

NOTE: All elevations are referred to low water datum elevation 570.5 feet above mean tide of New York City.

COOPERATIVE BEACH EROSION STUDY IN ASHTABULA AND KINGSVILLE TOWNSHIPS AND LAKEVILLE VILLAGE

STATE OF OHIO

APPENDICES · V & X · ASHTABULA COUNTY

PROPOSED PLANS OF IMPROVEMENTS

TYPICAL STRUCTURES

IN 7 SHEETS — SHEET NO. 6 — SCALE AS SHOWN

BUFFALO, N.Y. DISTRICT — JULY, 14, 1950

SUBMITTED — RECOMMENDED — APPROVED

Joseph H. Wermuth, CHIEF, PROJECT BRANCH — S. Ebert, CHIEF, ENGINEERING DIVISION — Frank H. Varney, COL., CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED AUG. 2, 1950

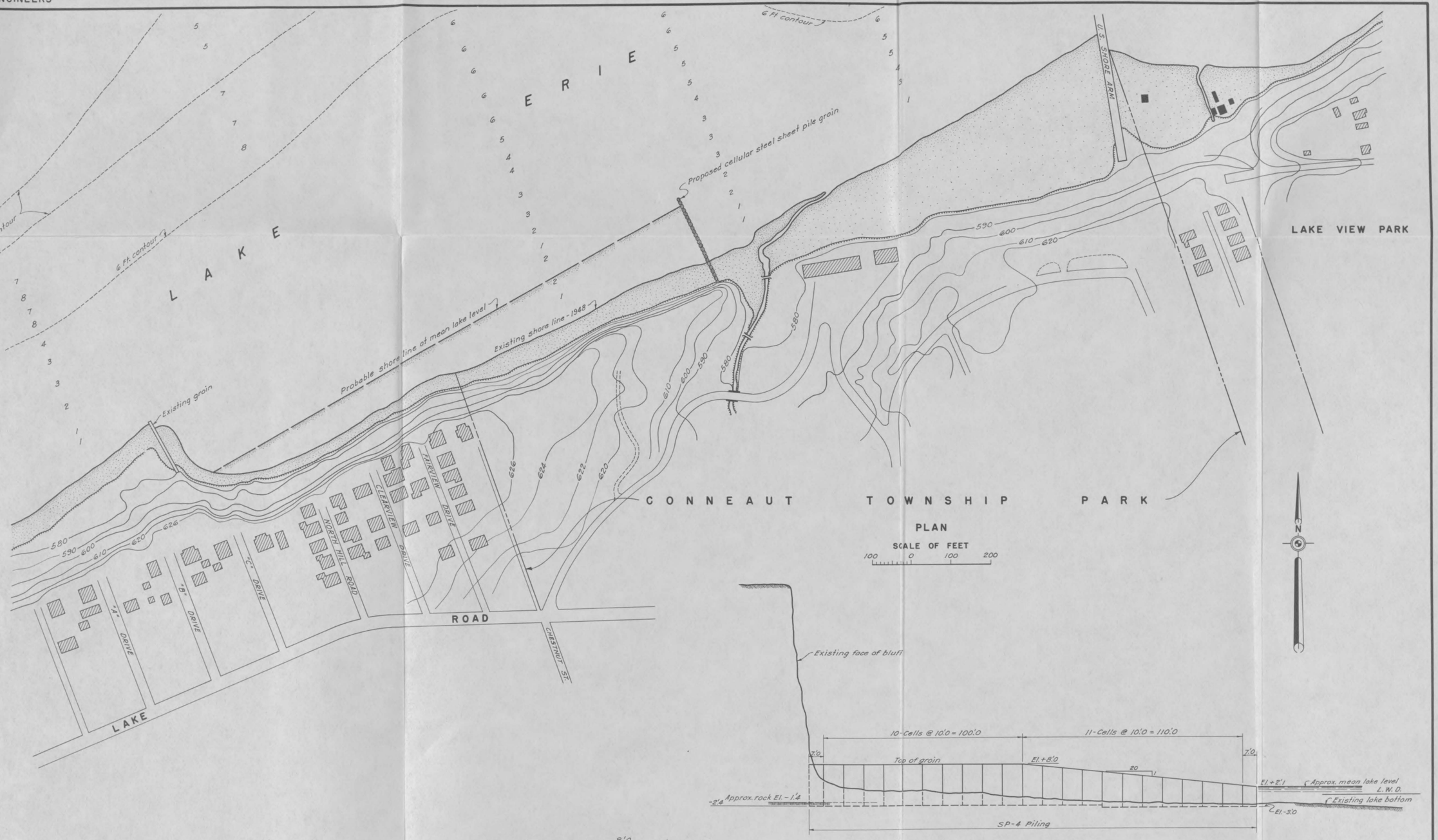
DRAWN R.D.P. TRACED R.D.P. CHECKED FILE NO.

PLATE 6

95139 O - 52 (fols. text) No. 2

CORPS OF ENGINEERS

U. S. ARMY



PLAN

SCALE OF FEET

100 0 100 200

PROFILE OF CELLULAR STEEL SHEET PILE GROIN

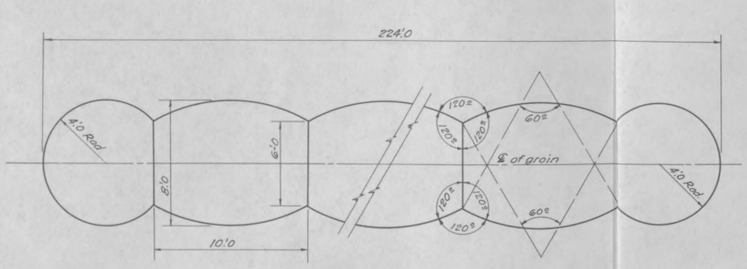
SCALE OF FEET

20 0 20 40

Horizontal

10 0 10 20

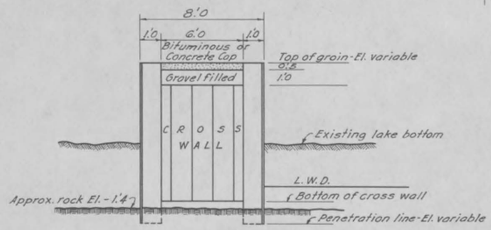
Vertical



PLAN OF CELLULAR STEEL SHEET PILE GROIN

SCALE OF FEET

4 0 4 8



TYPICAL CROSS SECTION

SCALE OF FEET

4 0 4 8

NOTE: All soundings and elevations are referred to low water datum elevation 570.5 feet above mean tide at New York City.

COOPERATIVE BEACH EROSION STUDY IN ASHTABULA AND KINGSVILLE TOWNSHIPS AND LAKEVILLE VILLAGE

STATE OF OHIO

APPENDICES · V & X · ASHTABULA COUNTY

PROPOSED PLANS OF IMPROVEMENTS

CONNEAUT TOWNSHIP PARK

IN 7 SHEETS | SHEET NO. 7 | SCALE AS SHOWN

BUFFALO, N.Y. DISTRICT | JULY, 14, 1950

SUBMITTED | RECOMMENDED | APPROVED

Joseph H. Wunsch, CHIEF, PROJECT BRANCH | S. Bellmont, CHIEF, ENGINEERING DIVISION | Ernest O. Pomeroy, COL., CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED AUG. 2, 1950

DRAWN R.D.P. TRACED R.D.P. CHECKED DK FILE NO.

PLATE 7

95139 O - 52 (fols. text) No. 3